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## Young children's understanding of design in the technology process

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**Young children's understanding of  
"design"  
in the technology process.**

by

Jean E. O'Sullivan Bachelor Arts Education (Early Childhood Education)

A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of Bachelor  
Education (Honours).

At the Faculty of Community Services, Education and Social Sciences,  
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## **ABSTRACT**

This study explored the development of children's thinking when social constructivist principles of learning were implemented through technological experiences. The study monitored the development of children's understanding of "design" through project work, using classroom based action research. In addition to investigating children's understandings, the study explored the use of technology in early childhood curriculum to develop the skills said to be required in the next millennium. The study found that five-year old children are capable of "designing" and that technology is an effective vehicle for developing socially, contextually and culturally appropriate learning experiences.

### **DECLARATION**

I certify that this thesis does not incorporate, without acknowledgment, any material previously submitted for a degree or diploma in any institution of higher education and that, to the best of my knowledge and belief, it does not contain any material published or written by another person except where due reference is made in the text.

Signature .....

Date .....

## **ACKNOWLEDGEMENTS**

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## INTRODUCTION

### Background to the Study

This study examined young children's knowledge and understanding of "design" in the technology process. The concept of "design" is abstract in nature and may be difficult for young children to understand. The study focused on technology as a means to develop a social constructivist approach to learning and teaching in early childhood education. There has been a world wide swing to the social constructivist approach to learning but constraints such as prescribed curriculum, space, time, materials and support, together with the lack of knowledge and understanding about children's thinking, may make it easier for early childhood teachers to talk about social constructivism than to implement it. However, supporting children in technological projects may provide a useful vehicle for developing understandings about the social constructivist approach to learning.

Technology is a recent addition to the early childhood curriculum, which may create difficulties for early childhood teachers who may be unwilling to include or accept changes to their traditional programs. However innovative early education programs in the United Kingdom, Europe and USA are challenging teachers to change their practices (Anning, 1994). It is said that the skills required by people in the twenty-first century will differ to those traditionally taught over the past two decades. Puckett & Black (1994) note that some of these skills are: the ability to communicate orally, in writing and technologically; the ability to cooperate, collaborate and negotiate; the ability to think critically and solve complex problems efficiently and the ability to view the human experience and our constantly changing world from a global perspective. These skills are



reflected in the Technology and Enterprise learning area, which allows planning to integrate developmental domains through a cross-curricular approach.

Recent Western Australian curriculum documents have emphasised the importance of skills, knowledge and positive dispositions in Technology and Enterprise (Curriculum Council, 1997). The draft of the Curriculum document for Technology and Enterprise describes children learning to apply knowledge, skills and resources in the development of practical solutions to problems. In the process of doing technology, children use trial and error to produce ideas. Children may use drawings and models to show their ideas and to explain what they have done. The draft document (1997) acknowledges that some curriculum specifications need to be adapted, to be a suitable inclusion in early childhood education.

Technology involves asking children to generate solutions to real problems. It involves thinking about creating or modifying things and using tools and resources in order to solve problems of the natural and made environments. Enterprise is the quality that enables one to be flexible, creative and adaptable in an ever-changing world.

### **Significance of the Study**

The 1993 National Curriculum Council for England and Wales recommended that technology education should be implemented in all government schools in England and Wales by September, 1995 (Anning, 1994). Anning analysed the interviews of twelve early childhood teachers struggling with implementing the recommendations and concluded that there was urgent need for research in this area. Anning noted that early childhood teachers need a great deal of support to implement technology programs.

The Student Outcome Statements were trialled in Western Australia between 1994 and 1995 and the Technology and Enterprise Learning Area Report (1996) documented trial teachers' anxiety about their ability to implement Technology and Enterprise in early childhood. Teachers expressed dilemmas about adopting a learning area approach when traditionally teachers program in developmental domains, rather than discrete curriculum areas. Anning's (1994) research shows that early childhood teachers are not comfortable adopting programs based on learning areas. Revision of the Curriculum Framework has been carried out, with implementation planned over a five year period commencing in 1999.

It is likely that early childhood teachers will need a great deal of help to understand technology and enterprise and how this learning area can be implemented successfully in early childhood settings. Fler (1997) emphasised that there is need for teachers to implement two dimensional and three dimensional planning experiences into their programs and called for more research in this area, which was an aim of the current study.

### **Purpose of the Study**

This study explored the development of children's understandings of the abstract concept "design" which may present difficulties for children and teachers. In addition, it explored the use of technology as a vehicle to support a social constructivist approach to learning in the early years curriculum.

Malaguzzi (1993) states that educators need to help children develop as thinking individuals by encouraging children to have ideas of their own. Dockett (1996) reminds us that learning is not a only "hands-on" but also "minds-on" process. In the social constructivist learning approach, teachers have multiple and overlapping roles as teachers, researchers and learners (Oldfather, 1994).

Fleer & Sukroo (1995, p.1) stress the importance of successfully implemented technology programs and noted that it "means engaging them (children) in purposeful activities which draw upon children's existing understanding and skills and moves them to more sophisticated knowledge and critical reflection of technological processes and products".

### **Research Questions**

The need to develop teachers' skills to implement Technology and Enterprise in the classroom and the ability of young children to understand the abstract nature of the term "design", lead to the following questions:

1. Do technology learning experiences help five year-old children to understand the abstract technological concept of "design"?
  - 1.a) What do five year-old children understand by the term "design" before specific technological learning experiences?
  - .
  - 1.b) What do five year-old children understand by the term "design" after specific technological learning experiences?

## **Definition of Terms**

The following definitions are to be used within the context of this study.

**Technology** involves children generating solutions to real problems. It involves thinking about creating or modifying things, and using tools and resources in order to solve problems of the natural and made environments.

## **Social Constructivist Learning**

Drawing on the theoretical framework of Piaget and Vygotsky social constructivism asserts that knowledge is constructed as a system of relations. Children revisit and repeat experiences and organise single event learning within a broader system of learning. The child constructs knowledge through a process of individual and social activity and interactions with peers and adults (Gandini, cited by Forman, 1997).

**Design** refers to any activity in which children make records of their plans or intended solutions. (MacNaughton, 1998, cites Forman)

**Pre-Primary** in this study refers to a Catholic Education System, full-time, five days a week, educational program provided for children in the year they turn five.

## **REVIEW OF LITERATURE**

### **Design and Technology**

Designing is the conceptualisation of a real or imaginary object. Shannon (1994) and Johnsey (1995) see "design" as the interaction between thought and action. Design is the mental process that may precede the drawing or making of that designed image. When young children draw, they make symbolic representations of something that exists, either in the real world or in their imagination. Often, drawing and designing are carried out simultaneously and "captured on paper" in the process. The design component happens before drawing whether or not one is consciously aware.

Most young children function at the concrete level, however when children are asked to design they need to think abstractly, which may pose problems for young children at differing levels of cognitive development. Piaget (Bukatko & Daehler, 1992) suggested that young children need concrete, first-hand experiences in order to construct new knowledge. Therefore, early childhood educators need to make the abstract design process real and meaningful for young children, which means linking design to their first-hand experiences.

### **Teachers' Perceptions of Children's Abilities and Understandings**

Research shows that some culturally acquired teaching philosophy may hinder the design process (Cross, 1992; Anning, 1994; 1997; Cadwell, 1997; Ebbeck, 1996). For example, there are differences in the expectations of children's cognitive capabilities. Banta (1980) suggested that by the age of nine years children engaging in building block construction can accurately represent their design intentions. However, the question can

be raised about the extent to which beliefs in children's capabilities to deal in symbolic representations, reflects culturally acquired philosophies of education.

Ebbeck (1996) supported Anning's notion that teaching philosophies are culturally acquired asserting, "theories are influenced by particular cultural values and beliefs of a society at any point in time" (p.6). For example, some teachers may find it hard to accept that the modelling of observations, drawings and designing are powerful teaching tools. In the current study the processes of designing and drawing are seen as separate, but related processes. Anning (1997) emphasised the importance of drawing skills in design and technology. Anning stated that "drawing offers a powerful mode for representing and clarifying one's own thinking and for communicating ideas to others" (1997, p.219). Design work requires drawing to be seen as important work however research shows that "drawing" is not accorded high status by children as they perceive it to be a time-filling activity occurring after completion of "real work" (Anning, 1994).

Children's perceptions that drawing is unimportant work may have been influenced by a common belief that teachers who model drawings repress children's creativity. Anning (1994) noted that many educators vetoed the modelling of drawing behaviour (which might have been seen as scaffolding by Vygotsky) as they perceived it to thwart children's creativity and to force children into adult modes of representation. However, Caldwell (1997) suggested that the modelling of observations and drawing for children does not constrain their imaginations by stifling children's creativity but allows children to notice and be aware of attributes such as shape, texture, contour, effect and expression.

Caldwell (1997) cautioned early childhood educators may shortchange young children because of they believed that children's their small hands, short attention spans and lack of technique, meant they are capable only of simple schematic drawings of dogs, cats, rainbows and mummies. Anning (1994) emphasises the place of modelling in the design process stating "It is only through direct intervention from the teacher that the concept of drawing specific parts of a proposed model, define in 2D exactly what materials are to be used to create the 3D outcome, is developed" (p.48).

Anning's studies documented the concerns of educators to teach the technological skills needed by children. Studies by Anning (1994; 1997) and Solomon & Hall (1996) stressed the importance of teacher knowledge and children's skill development in Design and Technology. Anning (1994) documented the progression in capability of graphicacy, evaluation skills and the handling of tools and equipment.

In addition to the value of modelling design through drawing, Anning's study (1994) stressed the importance of instructing children in the correct and safe use of tools, materials and equipment thereby enabling children to manipulate and use tools more effectively. It is interesting to note that the teachers in Anning's study thought that they did not have the skills to instruct the children in this area. It is concluded that it is important that teachers are taught how to instruct children in the use of tools, in order for Design and Technology projects to be successfully implemented.

Cross (1992, p.23) questioned the place of an "essentially creative process" in the design process model being implemented in England. Johnsey (1995) further suggested that educators may not share the same meanings for technological terms such as "design" and confusions may exist about the cyclical or linear aspects of the design process.

Anning (1994; 1997) asserted that children's completed projects need not be similar to their original design drawings.

The importance of the organisation and availability of materials and resources in the early childhood classroom is crucial to successful design projects (Sellar 1997). Sellar suggested that blocks, books, art supplies and other materials are stored and organised in an attractive and easily accessible manner are more likely to be used effectively. In addition, it is important to consider children's own sense of time and personal rhythm when carrying out projects (Hendrick, 1997). Therefore, teachers need to allow a generous allocation of uninterrupted time for design projects. In addition, it is also important to have sufficient work-space where children can work and not be distracted (Cadwell, 1997).

Siraj-Blatchford (1993) stressed the importance of presenting children with new experiences, but the teachers should begin with the familiar and move to the unfamiliar. Siraj-Blatchford, (1993, p. 19) Driver who asserted that "the most important single factor influencing learning is what the learner already knows". It is inferred that design projects are likely to be successful when they incorporate materials familiar to the children, their first-hand experiences, and their ideas.

Fleer (1997, p.51) discussed technological experiences in the early childhood curriculum that focuses on children's competencies and commented that:

"One of the absolute joys of being a classroom teacher is to witness the capacity of young children today to be able to think in a multitude of ways:



- to think creatively, critically, rationally;
- to question, explore, investigate; and
- to confidently and spontaneously assess the complexity of a task, and without any breadth of life experiences or knowledge bank, effectively develop techniques and products which are both possible and practical to meet required needs".

Oldfather (1994) examined teacher's understanding of children's thinking in the social constructivist process. Oldfather found that teachers need help to understand the importance of stimulating children's thinking processes. Oldfather stressed the importance of discussion and questioning techniques; wait-time for children's responses; children's prior knowledge; and the implications of Piaget's notion of conservation in children's ability to conceptualise understandings. Oldfather found that "children's inability to conserve frequently prevented a child from grasping a concept" (p.10). She stressed that teachers should not assume that children understand the meaning of particular vocabulary being used. Oldfather found that children made up their own explanations when they are unable to conserve.

However, some teachers may assume children's thinking is more limited than it is in reality. Ebbeck (1996, p.7) cites Berk saying "There is always the possibility that we underestimate children's abilities when we observe and assess them apart from their everyday social environments."

It is important then, that teachers take care, not assume or misconstrue children's conceptual understandings. Teachers need to know when to scaffold children's knowledge and when to allow children time to construct their own understandings. Research (Ebbeck, 1996; Anning, 1994; Low & Shironaka 1995; Oldfather, 1994; & Malaguzzi, 1993) shows that time for observation and a unhurried, child-driven curriculum underpin social constructivist learning environments.

### **Prescribed Curriculum in the Social Constructivist Classroom**

Anning (1994: 1997) supported the urgent need for early childhood teacher education in the implementation of technological learning experiences. Teachers need to provide young children with time, materials and repeated learning experiences based on children's interests and prior knowledge. The push-down curriculum may affect early childhood teachers who may be increasingly pressured to adopt formalised programs. Without support, teachers may be driven to implementing "technological learning experiences" in formalised, fragmented time-slots, instead of in a child-initiated, emergent curriculum that allows for repeated experiences with materials, support, scaffolding and plenty of time.

Studies on children's development and learning over the last two decades, support the proposition that the project approach is an appropriate way to stimulate and enhance children's intellectual and social development (Katz & Chard, 1989). Low & Shironaka (1995) examined an early childhood class in which children worked independently in a social constructivist, child-driven environment. The teacher in Low & Shironaka's research was committed to a project-work program and she saw her main goal as gaining new understandings about children's learning through social constructivism.

Technological project-work can be long term and child-initiated and with few pre-ordained learning outcomes. Outcomes are determined by individual developmental levels, interests, needs and strengths. However, some teachers may find that the pressure to accomplish certain curriculum goals and the uncertainty of "doing it right" creates difficulties for them.

Early childhood teachers need time to observe and scaffold children's learning and not to be constrained by predetermined "blocks" of programmed learning. Social constructivism does not fit with prescribed, hurried, fact-driven curriculum in young children's learning.

### **Social Constructivism in Practice**

The impact of culture on teaching philosophy, and in turn, on children's understanding and abilities is demonstrated in Italy's Reggio Emilia early childhood education programs. In Reggio Emilia, very young children design with apparent ease. The underpinning philosophy of Reggio Emilia reflects the theories of Dewey, Piaget and Vygotsky. In the programs in Reggio Emilia very young children are seen to be competent beings, and are taught complex technological skills and processes. Children complete many multi-faceted, in-depth designs, using a variety of media, when engaged in a project. Cadwell (1997) contends that Reggio Emilia schools may be the most thoughtful early education program in the developed world, and that students attending these schools are encouraged to be young scientists, designers and philosophers.

Pre-schools in Reggio Emilia in Italy adopt a social constructivist learning philosophy that stresses the importance of child-initiated learning. Berger, Berger & Pollman, (1996) define "constructivism" as "the invention or creation of knowledge by children interacting within themselves and with their environment. In the invention of knowledge, the child is able to see relationships, to problem-solve, to re-invent, to use logical thinking and to make decisions." (p.250).

In Reggio Emilia and the project-approach program of cooperation and collaboration among teachers, parents and children, encompasses social constructivist learning philosophy and emergent, child-owned curriculum. In Reggio Emilia children have many technological learning experiences and engage in the technological skill of designing (Firlik, 1996; Cadwell, 1997; McCarthy, 1995).

In Reggio Emilia, teachers know their students well, and this is the fundamental principle of the approach to learning and teaching. Teachers celebrate children's differing conceptual understandings. In Reggio Emilia programs both the teacher and the children bring knowledge and competence to planning, learning and assessment (Berk & Winsler, 1995; Gandini, 1993; Cadwell, 1997; Mc Carthy, 1995).

Reggio Emilia's founder Loris Malaguzzi, studied in Piaget's School for Young children in Geneva and at the Rousseau Institute and was inspired by Piagetian and Vygotskian theories (Malaguzzi 1993). Malaguzzi stressed that five-year old children are "concrete" thinkers and have difficulty with abstract notions. Children's knowledge is built out of "hands-on" experience. Knowledge is not static but constantly changing and increasing with physical, linguistic and social experience.

In accordance with the literature discussed, the current study incorporated the following practices, in order to enable children to develop their knowledge about design in the technology process. Firstly, different levels of cognitive and physical ability of individual children were expected. Secondly, the present study also included teacher-modelling of observation skills, designing and drawing processes. Thirdly, a generous allocation of uninterrupted time for project work was provided. Fourthly, the availability of sufficient work-space for design projects was ensured. Fifthly, this study provided children with free access to a wide range of well organised materials and finally, the study ensured that children were instructed as to the safe and correct use of tools and equipment.

## THEORETICAL FRAMEWORK

Current understandings about children's cognition and learning have been informed by the work of theorists such as Piaget and Vygotsky. Piaget asserted that children develop as they pass through certain, definite, recognisable stages. Children use prior knowledge to actively construct new knowledge as they manipulate and explore their world. Piaget stressed that what a child knows will determine the child's ability to construct knowledge schema (Bukatko & Daehler, 1992).

Duckworth, cited by Oldfather (1994), considers the essence of intellectual development as "the having of wonderful ideas". Duckworth argued that the most important lessons to be learned from Piaget do not have to do with the designation of stages, or how to accelerate the development of children's ideas, rather, the critical concern is that teachers need to learn how to assume a posture of "being Piaget" where:

the main thing...is the focus on how children are making sense of the situation in their own way. To the extent that one carries on a conversation with a child, as a way of trying to understand a child's understanding, the child's understanding increases in the very process (Duckworth, 1989, p.87).

Vygotsky asserted that children construct their knowledge and values as a result of interactions with the physical and social world (Berk & Winsler, 1995). In social constructivist learning children construct their knowledge and values as a result of interactions with the physical and social world. They use prior knowledge to actively construct new knowledge as they manipulate and explore their world and use dialogue as

an important tool that children use to make sense of their world. Teachers' knowledge of a child's ZPD in conversations can enable them to assess and accelerate learning. Children need a wide range of media with which to express their ideas and their understandings and access to an adult who will interact with them to scaffold their knowledge (MacNaughton, 1998).

Vygotsky stressed that cognition leads development and the importance of the socio-cultural context in the child's construction of knowledge. Vygotsky asserted that the internalisation of learning within the zone of proximal development (ZPD) occurred as a direct result of social interactions with adults or more competent peers. The zone of proximal development can be described as the difference between what a child can do on his/her own and what he/she can do with the help of a more capable peer or adult (Berk & Winsler, 1995).

Gardner's theory of multiple intelligences (Gardner, 1983) is reflected in Reggio Emilia's "One Hundred Languages" of children (Malaguzzi, 1993). Gardner's theory acknowledged that people learn, represent and utilise knowledge in different forms. Gardner claimed that all human beings are capable of at least seven different ways of knowing the world; through linguistic, logical-mathematical analysis, spatial representation, musical thinking, the use of the body to solve problems or to make things, an understanding of other individuals, and an understanding of ourselves (Gardner, 1983). Gardner's definition of intelligence includes the skill of solving problems or fashioning products, which are valued within one or more cultural settings (Bukatko & Daehler, 1992).

Piaget, Vygotsky and Gardner stressed that the basis for learning is the acceptance of individual differences; opportunities for active participation; and the construction of knowledge by children through active participation and problem solving (Ebbeck, 1996).

Technology and Enterprise experiences aim to develop learning through the roles of facilitating and scaffolding, which occurs as a result of the teacher's assessment of children's understandings. Metacognition is associated with successful learners. It refers to an individual's awareness and ability to monitor their own thinking processes. As teachers model thinking aloud and verbalise specific, teaching/learning strategies, they enable children to see the reasons for certain activities. Children see the link between actions and thinking (Gage & Berliner, 1991). However, prior research, shows that teachers are unsure of how to assess children's thinking (Anning, 1994; Ebbeck, 1996; Low, 1995 & Oldfather, 1994). An aim of the current study is to give insights into children's thinking and understandings about "design".

### **Classroom-Based Action Research**

Classroom-based action research is a way of approaching a study which allows the teacher-researchers to examine the knowledge-base, intentions and motivations of the children they teach in their own social context. Case studies allow a researcher to "capture the social reality" (Burns, 1997, p.300) of the situation of the group. This study will employ action research to study a social situation and to improve the quality of action within it (Elliott, 1978).

Case studies allow for the collection of rich data in naturalistic settings (Burns, 1997). Action research allows the teacher-researcher to gather information through



informal interviews and through participant and non-participant observation (Shulman, 1981). It allows teachers to step back from the traditional role and to ask themselves and the children questions, such as "What exactly is happening here?"; "Why is this happening?" and "Why are you doing this?" Action research can lead to improving the quality of instruction within a classroom by testing and validating educational theories and strategies in concrete situations (Burns, 1997).

Action research allows for the collection of a wide range of data including, on-site recording of child-teacher interactions, audio and video recordings, photographs, journal entries and the collection of work samples, all in a naturalistic setting. Case studies allow for time-series-analysis (Burns, 1997) which accommodates children's dynamic, developing knowledge. Data can be sorted to identify major understandings that emerge from the data and patterns in children's understandings can be identified, categorised and recorded. Reliability and validity of a study can be optimised by triangulation of data.

Anning (1994; 1997) and Solomon & Hall (1996) discussed the importance of teacher knowledge and children's skill development in Design and Technology. Solomon & Hall (1996) recognised that Technology education may be a difficult area to implement and stress the importance of linking data from small-scale teacher action research with cognitive psychology in an effort to aid the teaching of primary technology. The current study aims to aid research in this area by documenting five-year old children's understanding of design before and after specific technological learning experiences.

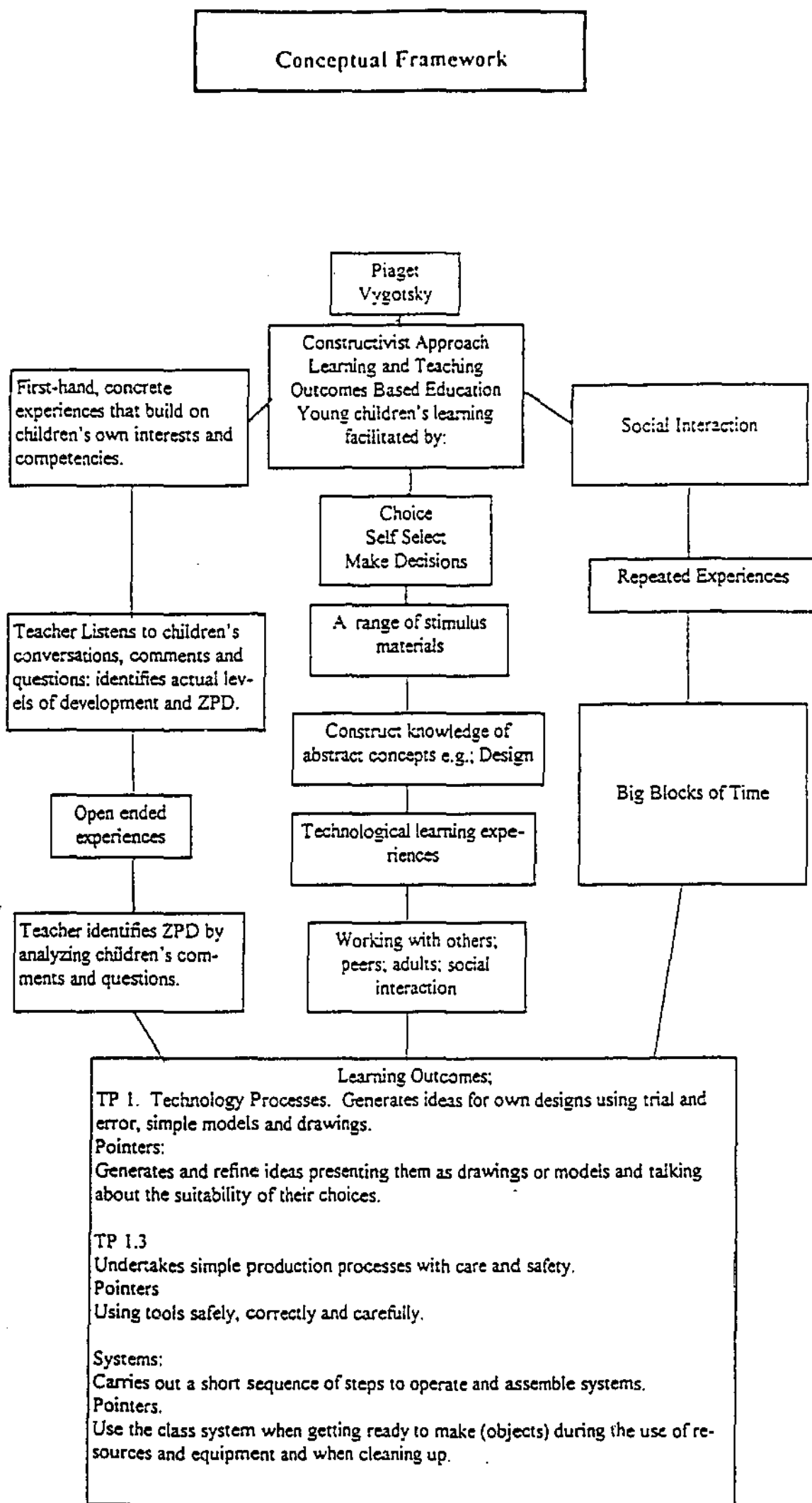


Figure 1. Conceptual Framework

## **METHOD**

This study monitored the development of children's understanding of the term "design" through project work. The study involved pre-primary children 'doing technology' in project-based work. It documented children's different understandings and made links to theories of children's cognitive development. The researcher in this study was the pre-primary children's regular teacher and the study was conducted as part of the teacher's classroom program. Permission for the study was gained from the principal and parents of children in the class. The study was conducted over a six-week period and explored the development of children's understanding of the term "design" as used in the technology process.

### **Participants**

The participants were 10 children who were turning five during the school year and attended five, full school days a week. All children in the class were involved in the technology project but the focus children were selected at random. The class comprised fourteen girls and sixteen boys all turning five in the year. The participants were chosen by selecting every third child on the classroom register. The focus children comprised two girls and eight boys.

### **Procedure**

The study consisted of ten steps which emerged as the teacher responded to the children's construction of knowledge and understandings, their motivations and dispositions.

In the first step, the children's understandings of the term "design" were clarified through informal one-to-one interviews with the ten focus children. An interview schedule was used to guide the interviews between the teacher and individual children. The interviews were conducted on the verandah of the pre-primary centre, a place where the children often sat and chatted with their teacher in a quiet, pleasant, comfortable and relaxed setting. The interviews were audio-recorded, transcribed and analysed.

In the second step, a project was developed in which two main learning experiences were developed that included a large component of "design". The experiences were developed, based on the children's understandings, knowledge and experiences. The teacher decided the first experience would involve designing and building using blocks as a medium. The second learning experience involved the children designing and building using "junk" materials. The project was conducted half way through the school year and the children were familiar with both of these mediums.

The third step involved setting up the physical environment for project work. The teacher involved the children in this activity to stimulate their interest and curiosity and motivate them to be involved in the project. This step involved reorganising the classroom to make space for the project work and to make all materials readily accessible to the children to allow responsibility and autonomy.

The fourth step saw all children being instructed in the safe use of fastening devices and in the use of the woodwork bench and tools until they were skilled and confident. These skills allowed the children to be autonomous, to work independently, to solve problems of fixing and to persist in the face of difficulties.

The fifth step consisted of a whole-group brainstorming session to find out what the children already knew about the term "design", ending in a discussion of how they might find out more about it.

Next, a walk around the school and the block was undertaken to view aspects of design in our own environment. The children were asked to discuss "design" with their families before the next session when these findings would be discussed.

The seventh step consisted of another whole-group discussion of the findings. The teacher and children looked at and discussed books showing designs. Children's clothing design were compared and discussed. During this session the teacher modelled the design of a block construction then the structure was built with constant reference to the design plan. Finally the construction and the design plan were compared.

The eighth step lasted many days when all the focus children and others set about designing and building using blocks. The children were asked to design and build a block structure. They chose to work independently on this project, which they repeated many times in a five-day period. The children were encouraged to hypothesise, problem-solve, analyse, and synthesise as they designed. Children were asked to construct a concrete object from their design and structures were displayed and photographed. The children were encouraged to assess and evaluate their designs.

The following week the ninth step began. A whole-group discussion was conducted to clarify the children's growing understanding of "design" and included the

use of the design process when constructing objects made from "junk" materials. A topic web was developed with the children, based on their current interests. The children's interests fell into four categories; hats, wheeled vehicles, rockets and animals.

The ten focus children were chosen to embark on their project work first, whilst the rest of the class were involved in other, self-chosen activities. Children self-selected into collaborative groups to undertake a project using "junk" materials of interest to them which aimed to encourage motivation, autonomy, initiative, independence, and self-sufficient thinking. Children were actively involved in a physical and mental sense. Their interests drove the tasks and their responses were scaffolded by constant checking of their understanding. Of the ten focus children, three chose to design hats, three chose to design wheeled vehicles, three chose to design rockets and one child chose to make a hedgehog. The children worked in three groups of three, according to their interest category, but one of the children chose to work alone. The children were encouraged to hypothesise, problem-solve, analyse, and synthesise as they designed. They were asked to construct a model from their design. The constructions were displayed and photographed and children were encouraged to assess and evaluate their designs.

Finally, the tenth step re-assessed the children's understanding of the term "design" at the completion of the technology-project, in one-to-one interviews with the teacher. Although the tenth step marked the end of data gathering, the children returned spontaneously to the design process, ten weeks later.

Interviews, development of the project, assessments and final interviews were conducted by the classroom teacher.

## **Data Collection**

This study provided multiple sources of evidence of children's understandings which allowed for triangulation thus improving reliability and validity of data. The study maintained a chain of evidence of children's initial understanding of the term "design" to the children's understandings at the completion of the project. On-site data recording ranged from notes of child-teacher interactions whilst involved in technology through to audio and video recordings, photographs and digital camera records, journal entries, and the collection of work samples. Informal taped interviews were conducted with children in order to explore their underlying conceptual structures and to examine the structure of children's logic.

The following factors were considered during data collection:

- Data were collected in a pleasant and relaxed setting and the use of words, body language and facial expressions were considered.
- Open-ended questions were used to encourage children's continued thinking and risk-taking.
- "How" and "why" questions in response to student's comments were used to encourage elaboration and deeper thinking.
- Children were asked "how" and "why" they chose to do certain things.
- Children's own responses were repeated or paraphrased to encourage continued thinking.
- Children were asked "Tell me more about..." and "Why do you think that?" asked in a accepting yet curious tone
- Substantial "wait-time" was allowed for children's responses.
- Communicating a judgment about right or wrong answers was avoided.

## **Data Analysis**

In accordance with Burns (1997) guidelines for adequate case studies, there was the triangulation of data gathered from children's interviews, teacher and teacher-assistant journaled observations and work samples. Data was sorted to identify major understandings that emerged. Patterns in children's initial understanding of the term "design" were identified, categorised and recorded. The study involved time-series-analysis (Burns, 1997) which accommodated children's dynamic, developing knowledge.

Transcripts were made of audio recordings and observations and transcripts made from video recordings. Digital camera records of working processes were annotated and work samples and journals documented. Observation notes and journal entries were also documented. Student responses were analysed and care was taken not to assume or misconstrue children's conceptual understandings.

## **Reliability and Validity**

The use of triangulation facilitated the validity of the researcher's perspective and understanding. However, reliability and validity may have been affected by the following factors:

- Objectivity may have been affected by the teacher-researcher's own theoretical framework which may have shaped interpretations of children's responses.
- The teacher's assumptions may have misconstrued children's conceptual understandings.
- The teacher's questioning skills may have affected children's responses.



## **ETHICAL CONSIDERATIONS**

Ethics clearance was obtained prior to the study commencement date.

Pseudonyms were used for the participants.

## RESULTS

Name	Gender	Age (in years and months at the beginning of the study)	Fine Motor Skill development D- Developing C- Competent	Social Skill development D-Developing C-Competent	Oral expression ability D-Developing C- Competent
Mark	Male	5:2	C	C	C
Henry	Male	5:4	D	D	C
Erin	Female	4:11	C	D	D
Joseph	Male	5:4	C	C	C
Jeffrey	Male	5:5	C	C	D
Jake	Male	5:1	C	C	C
Seb	Male	4:11	C	C	C
Myles	Male	4:11	C	C	D
Rose	Female	5:4	C	C	C
Mitch	Male	4:11	D	D	C

Table 1.  
Details of pre-primary children involved in study.

The above table shows assessment of the children involved in the study, based on established developmental criteria. Oral language assessments were made using the First Steps Oral Language Developmental Continuum (1993), while social and fine-motor skill development was assessed using developmental benchmarks suggested by Puckett & Black (1994). Six of the children had turned five close to the beginning of the study, whilst four turned five within the following month. As shown in table 1, the fine-motor skills of two children and the social development of three were less developed than the others, whilst two of the children had oral language difficulties.

Step 1. Analysis of individual interviews before the implementation of specific "design" learning experiences.

Table 2. Children's initial understanding of term "design" before specific learning activities.

No.	Child	Immediate recognition of term "design".	Word context development	Confuses "design" & "build".	Prior knowledge of specific design experience	Discusses design of prior project	Draws in air to describe design	Draws before making	Discusses aspects of 'planning' or "design"
1	Mark	Yes	Yes	Yes	Yes	Yes	No	Yes - using a lead pencil	Thinking Planning Drawing Imagining Visualising Evaluation
2	Henry	No	Yes	N/A	No	Yes	No	?	Decision making Thinking
3	Erin	No	No	N/A	?	?	N/A	No	?
4	Joseph	Yes	Yes	No	Possibly	Yes	Yes	Yes	Drawing Thinking Imagining Planning Techniques Tools
5	Jeffrey	No	No	N/A	No	No	N/A	No	?
6	Jake	No	No	N/A	No	No	No	No	?
7	Seb	No	Yes	No	No	No	No	No	Thinking
8	Myles	No	No	No	No	No	No	No	Thinking
9	Rose	Yes	No	No	No	No	No	No	Imagining Planning Materials
10	Mitch	No	No	No	No	Yes	No	Yes - to inform others	Thinking Drawing

The children's understanding of the term "design" was clarified through informal one-to-one interviews with the children. Interviews were audio-recorded, transcribed and analysed. As shown in table 2, children demonstrated many differences in their understanding of the term "design" in the initial interview.

Mark showed initial understanding of the term "design". He was confused between the terms "design" and "build" but when the term "plan" was used his understanding was shown. This child appeared to have had extensive personal experience with a real design problem, for example he spoke of designing a tree-house, at home with his father. Mark's understanding of the abstract nature of designing was shown in the following conversation:

Mark: "You use a pencil that's not coloured" (a lead pencil). *You think about it in your brain."*

Teacher: "Is that hard to do?"

Mark: "No. Not very hard for me because I once drew some plans for my tree house but my dad never built them."

Teacher: "Your dad didn't use those plans?"

Mark: "No."

Teacher: "I wonder why he didn't use those plans?"

Mark: "Because they would make the tree house too heavy and it (i.e. the tree house) might fall down."

Mark's design plans were not used for the building as they would have made the tree unsafe but Mark appeared to understand this and accepted his father's decision.

Henry had no initial understanding of the term "design". He thought that the term meant "good":

Teacher: "Tell me what design means."

Henry: "Good".

Teacher: "What do you think people have to do when they are designing things"

Henry: "Um, be good"

Once the term "design" was combined in a sentence together with the word "make", he made some sense of the word, linking it with decision-making and thinking:

Teacher: "When you make things, do you design them first?"

Henry: "Yes."

Teacher: "How do you do that?"

Henry: "I decide....you need to think...you need to make a good thing"

It seems that Henry used his knowledge of syntax to construct a meaning for the term "design", and it appeared that he had little personal experience of the term.

Erin appeared to have little understanding of the term "design":

Teacher: "Do you know what design means?"

Erin: "No."

Teacher: "If I asked you to design something, what would you do?"

Erin "Do it straight away."

Erin demonstrated that she did not consciously design before she made things:

Teacher: "When you make something, what do you do first?"

Erin: "You get the things out and then you make them."

Teacher: "Right, and do you do anything else before you make it?"

Erin: "You let it dry".

Joseph had a well-developed concept of design although he could not always articulate his knowledge:

Teacher: "Joseph, how did you know that design means to design something to make?"

Joseph: "I don't know, it just came out of my head."

Joseph linked design with planning with design demonstrating this when asked:

Teacher: "What do you have to do when you design something?"

Joseph: "I'd write a plan."

Teacher: "Why do you think people design things before they make them?"

Joseph: "So they know what to build."

Joseph linked design with making and building, thinking hard, imagining, drawing, materials, techniques and tools. Joseph told of his use of design in his project work.

It appeared that Jeffrey had no understanding of the term "design". Even when the term was used in a variety of contexts he demonstrated no understanding of the word. Jeffrey gave no evidence of planning or designing before making something.

Jake seemed to have no understanding of the term "design". The word was placed in a variety of sentence contexts but he still seemed not to understand. Jake made no link between designing and making things, and said he never drew before he created aeroplanes:

Teacher: Why don't you ever draw a picture of what you're about to make before you make it?

Jake: "I wouldn't need to because it's easy."

One infers he made aeroplanes designed previously by himself or by someone else.

Seb showed no initial recognition of the word "design" however after discussing building with Lego, he associated (and used) the word design as something you need to think about before building.

Myles showed little understanding of the term "design" throughout the interview. When discussing "making" he realised the need to think about what one was to make.

Rose understood the term "design" immediately. She knew that design involved "making things up", planning, materials and techniques but said she never drew before she made an object.

Mitch demonstrated no understanding of the term "design" throughout the interview. He said he did draw before commencing a project, although he said it was to inform other people of what he was making. Mitch only links drawing with the finished product but not the processes involved in design.

### **Summary of first interviews**

Of the ten children studied, three children immediately recognised the word "design" and understood that it involved planning and thinking. One of these children (the child of an engineer) had been involved in specific design activities related to the building of a tree-house at home. He knew that design involved thinking, planning, drawing, imagining, visualising and evaluation.

A second child with considerable design knowledge (again, the child of an engineer), knew that design involved drawing, thinking, imagining, planning, techniques and tools. The knowledge of the third child recognising the term "design" was more limited but she knew that designing involved imagining, planning and materials.

Seven of the children had no concept of the term "design" at the beginning of the interview. Two of the seven children showed some understanding of the word "design" when it was linked to "planning". Two of the remaining five children knew that "planning" involved thinking whilst the remaining three children showed no understanding of "design" (even when it was linked to "planning") throughout the interview.

Only three of the children professed to "drawing" before the commencement of a project. One of these children said that he drew to inform others of what he was making whilst another said that one must use a lead pencil.

From these interviews, it was apparent that the prior knowledge of these five year old children varied greatly, with three of the ten children studied having good prior knowledge, four having very limited knowledge, and three having no prior knowledge.

## **Step 2. Project construction.**

The learning experiences were decided by the teacher based on the above analysis of the children's knowledge of the term "design". The teacher decided that the first major learning experience would involve the children in block design as it was a medium with which they were very familiar at that time of the year. The second major learning experience involved the children in designing using "junk" materials.

## **Step 3. Setting the scene for the project.**

The project-work began by "setting the scene". The children were involved in creating an environment that would inspire them to design. The teacher and children



surveyed the classroom in its usual arrangement consisting of the book corner, block area, puzzle shelves, writing centre, a large collage table and tables and chairs in set up in groups. This seemed cluttered and the teacher, assistant and children decided that more open space was needed. The children helped with the moving of the block shelves to an open area, the grouping of the tables to make another large work area (to complement the large collage table) and they helped to put away of the home corner to create more space.

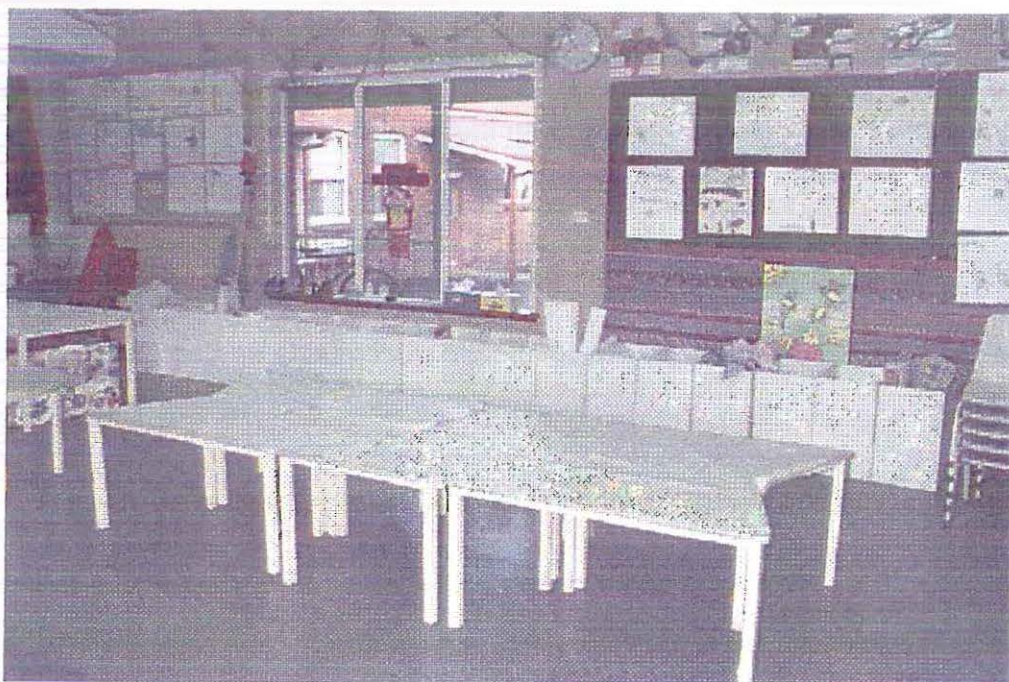


The children began assembling and strengthening twenty cartons in which a variety of materials could be stored and be easily accessible to the children. The children dragged the cartons to and from the storeroom filling them with different materials to be used in technology projects. The children showed delight in this activity as they saw many materials that had, to date, been out of sight and locked in the storeroom. The process appeared to create ownership and motivated the children to be involved in the study as shown by films and audio-recordings of this activity.



Jake showed his interest in the technology projects by stating: "Wow, this (corrugated cardboard) will be great for building trucks and these (cylinders) will make great pipes. We're going to have great fun, aren't we?" Rose was also motivated for the project by this activity as she commented while dragging a box filled with fabric: "We could make real clothes with this. All we need is masking tape and wool. When can we start working in our work-shop?"

The teacher and children moved everything away from one wall and placed the cartons against it. A low window sill was used as a shelf for fasteners and the collage trolley filled with small items that the children might use. The collage table and the grouped tables formed a large work area that provided a great deal of space to allow the children freedom to be creative.



When the changes were completed the classroom looked pleasing and inviting and everything was readily accessible to the children. Not all children chose to be involved in Step 3 and some were involved in many other self-directed activities both in and outdoors.

#### **Step 4. Instruction in fastening devices and woodwork.**

Parents were invited in to help to teach the children the skills they needed to use various fasteners, for example; different types of glue and its application, sticky tape, scissors and fastening devices such as split-pins, paper binders and paper clips. Many of the children had not seen some of the fastening devices used before and appeared delighted by their discoveries. One child, Mitch, shrieked with delight "Look at what this can do!" as he discovered the ability of file-paper binders to hold tubes and boxes together with a trailing-action, whilst another child, Henry, carefully considered the best adhesives for various jobs: "This strong glue will be good for holding this heavy cardboard on, but I'll need to use a split pin to join these (two pieces of cardboard needing mobility) together."

During this activity, some equipment was found to be faulty, thereby hindering the children's autonomy, for example, the cutting edge of one tape dispenser was blunt, whilst the reel, holding the roll of tape in another kept coming out as the children tried to dispense tape. The malfunctioning equipment led to frustration by the children and the parents, and lessened the children's interest in the activity.

The teacher-assistant, grandparents and parents were involved in educating the children in the safe use of woodwork tools, for example; hacksaws, G-saws, bench hooks, vices, hammers and nails. Teaching these skills was carried out over a period of three days and as a result all children were able to use materials, equipment and tools needed for the technology project.

During this time, children built and made structures from junk materials, as usual. but the ten focus children did not design formally before construction even though "design" had been discussed in the interviews. The children appeared to be very interested in their newly created "work-shop", the array of readily accessible, "junk" materials; and in using their recently acquired "fastening" and woodwork skills.

#### **Step 5. First Whole-Group Session.**

The first whole-group session attempted to discover what the whole group already knew about design. Previously, ten children randomly selected for the project had been interviewed regarding their prior knowledge and they were part of this group. The interview schedule used for these ten children was used to guide the discussion with the whole class.

The ten focus children, who had been previously interviewed, were the only children who appeared to have any understanding of the term design. Generally, the whole group did not appear to have much understanding of the term "design" and little information was forthcoming. Most children could not make any links to their own experience about design and appeared disinterested and off-task. When asked about their understanding of the concept of design, children's responses included: "putting things together", "gluing things together", "build something" and "you get some sticky tape and you stick it together." The whole-group's apparent lack of understanding may have been because the interviews with the ten children were carried out in a one-to-one situation as opposed to a whole group discussion.

During the whole-group session a number of children were off-task as shown by small acts of disruptive behaviour such as one child who rocked with his gaze fixed somewhere in the distance. Children were inattentive and appeared bored. It seemed they knew little about the subject and could not make links to their own experiences.

During the discussion, some children did seem to develop some understanding of "design" when used in the context of a sentence:

Teacher: "We usually design things before we make them. Who can tell me what we might do when we design?"

Mark: "Well, you have to think about what you're going to make."

Michael: "You have to think about it in your head."

Children related design to building and making things and to thinking about things. The children quickly developed contextual understanding and responded eagerly to the positive feedback the teacher gave to appropriate contributions. One child told the class that he did draw at home before he built and demonstrated the drawing of a design "in the air". As the project progressed, this child became very interested and involved in designing. He designed daily, but only designed and built block structures. Another child said that he did not draw his design before he built but he did think about it in his head. When the children were talking about "designing in their head", their eyes appeared distantly focused and usually turned to one side or even closed in the effort of concentration.

Brainstorming showed that as a group, they knew very little about design. The children and the teacher then discussed how to find out more about it. Some children

suggested they could ask their parents, some suggested they could ask the teacher and were surprised to find that she knew very little either. It was decided to visit the library and walk around the school and the neighbourhood in order to look at aspects of design in the environment.

#### **Step 6. Walk around the environment.**

Next, a walk around the school and the block was undertaken to view aspects of design in the children's own environment. The teacher and the assistant began by pointing out aspects of design in the school buildings, the pavement and gardens and it was not long before the children began to point out designs as they recognised them. Designs most recognised by children appeared to be that of roofs and whether they were "pointed" or "flat":

Mitch: "That one's got a very pointy roof."

Jeffrey: "There's a flat top on that one."

Henry: "All the houses in this street have flat roofs."

Their "label" related to the way in which the gable was being viewed. The children also noticed aspects of design in flower gardens where rows of flowers had been planted according to size and colour.

Rose: "The flowers in that garden are in stripes (of colour)."

Joseph: "Look at that one (garden), it's in a star design."

Jake: "This garden is boring. It's got straight lines (the shape of the garden beds)."

#### **Step 7. Second whole-group session.**

After visiting the library, and walking around the neighbourhood to look for aspects of design, the class gathered as a whole group to discuss the findings. Children

did not seem to know much about design, commenting that "design is building things" and "it's gluing things together to make something," although some children linked the aspects of planning and pattern, shown by the following comments:

Mitch: "It's whether houses have a pointy or flat roof".

Erin: "You can see patterns in the gardens if you have a good look."

During this whole-group session, it was interesting to note the difference in the children's concentration compared with the first session. The children sat still and appeared interested and focused. There was no sign of the small acts of misbehaviour evident in the first session.

Children discussed what they had found from their parents about design, which was very little, and they looked at books found from the library. One book showed different designs for puppets. A discussion took place about children in the class who were wearing wind-cheaters of the same design but different colours. When discussing whether the wind-cheaters were the same design or not, most children thought that they were the same. Most knew that the difference in colour did not change the design. Children noticed that the wind-cheaters had the same motif on the front, that they were made of the same fabric, that they both had stretchy ribbing at the neck, cuffs and bottom and that the writing was white. One child commented that they were "just different colours but they were the same design". It was interesting to note that the children appeared to be far more focused during this discussion, shown by on-task behaviours such as involvement in discussions and constant eye-contact. Increased on-task behaviours may have been due to the use of the book as a stimulus/motivation or the use of children themselves to demonstrate design.

During this session the topic of designing a block structure was discussed.

Children were very familiar with blocks and had five months experience of building with them. It was interesting to note the children's increased attentiveness during this session. The teacher modelled the mental processes involved during the design phase. These included; thinking, considering options, visualising objects and spaces, drawing ideas, organising materials and planning and safety procedures.

The teacher used "thinking aloud" to considering the availability of materials and how it can affect what can be designed and made. The teacher knew she would make a block structure but not exactly what she would build. The teacher asked children for suggestions and finally settled for a building. A design brief was discussed limiting the building to a certain number of blocks as the teacher thought that it would be best to limit the children to a certain number of blocks when they designed.

During the designing, the teacher modelled looking at the block shelf and at the different shaped blocks available. She modelled "thinking aloud" about the options available and from where the designing might start. She chose to begin drawing the design of the floor structure using flat rectangular blocks. The teacher then modelled drawing the design, thinking aloud so that the children could see the thinking processes involved. All the children were very focused during this learning experience, and no inattentive or disruptive behaviour was evident.



After modelling the design of the block structure, the teacher moved over to the block shelves and the children watched the building of the designed structure. The children and teacher discussed where the building would begin and where the design had begun – with the flooring:

Teacher: "Now where did I begin drawing the design? Oh! That's right, I began at the bottom of my structure."

Mark: "Yes, at the floor, with those big flat blocks."

Teacher: "Then, which blocks do I need to start building with?"

Henry: "With the flat, rectangular blocks."

The teacher referred constantly to the design plan during the construction process, and eventually, the children were going to the block shelf to pass the next block needed, showing that they had followed the plan for the building. The design of the building needed to be changed along the way as the teacher ran out of the blocks she had planned to use. The teacher did not amend the actual design plan.

When the structure was completed the children seemed very keen to look at it and to compare the building with the design plan. The fact that the building did not exactly comply with the design brief was discussed, but the children seemed unconcerned. The modelled block structure used more than the number of blocks allowed and counted in the teacher's design plan which was because she had only counted in two dimensions and not in three dimensions. The teacher emphasised the dilemma in using too many blocks but the children said it did not matter and that it looked great anyway. It was decided not to limit to children to a certain number of blocks as it had been a difficult task for an adult.

### **Step 8. Designing and building using blocks.**

At the end of the session, the teacher suggested that the children might like to design and build block structures just as the teacher had done. The ten focus children were directed to do this, but the rest of the class had a choice and they responded with enthusiasm. Many children set about making designs using blocks and building them. The children were encouraged to hypothesise, problem-solve, analyse, and synthesise as they designed. The children were encouraged to assess and evaluate their designs. Design plans were collected and annotated and children were photographed with their structures. One child, Myles, designed and accurately followed the plan to build a photocopy machine. He was able to discuss his design plan, pointing to the relevant parts of the structure:

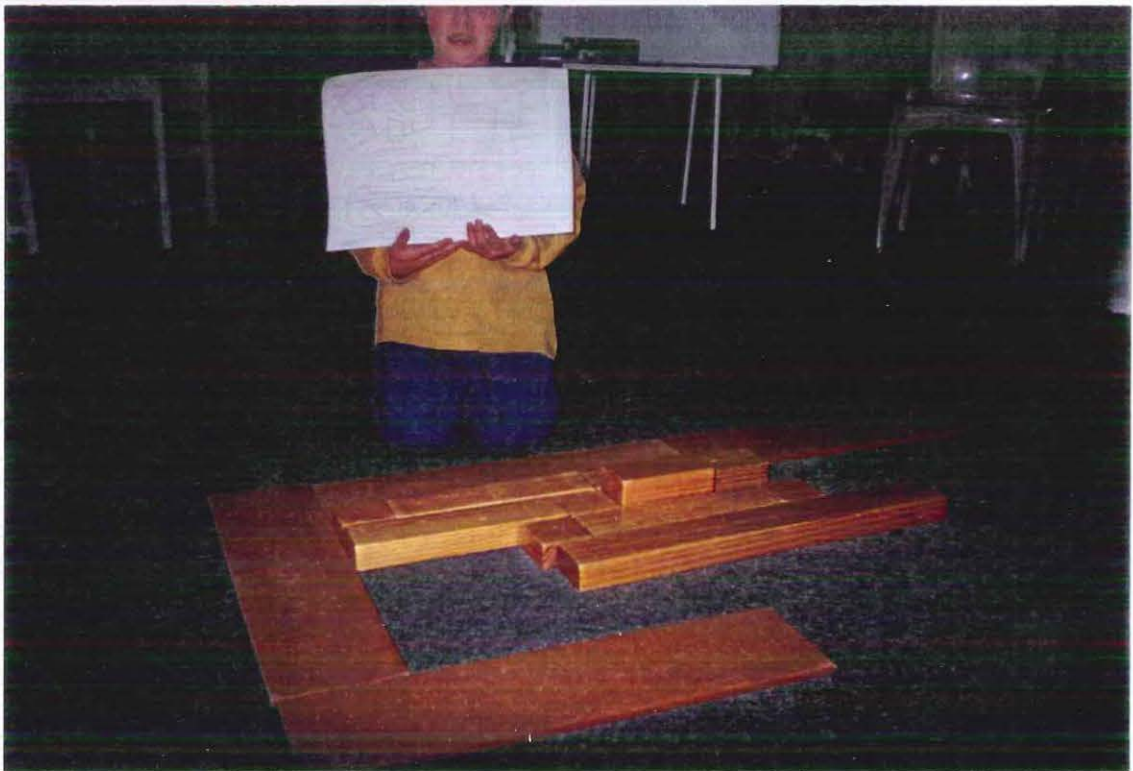
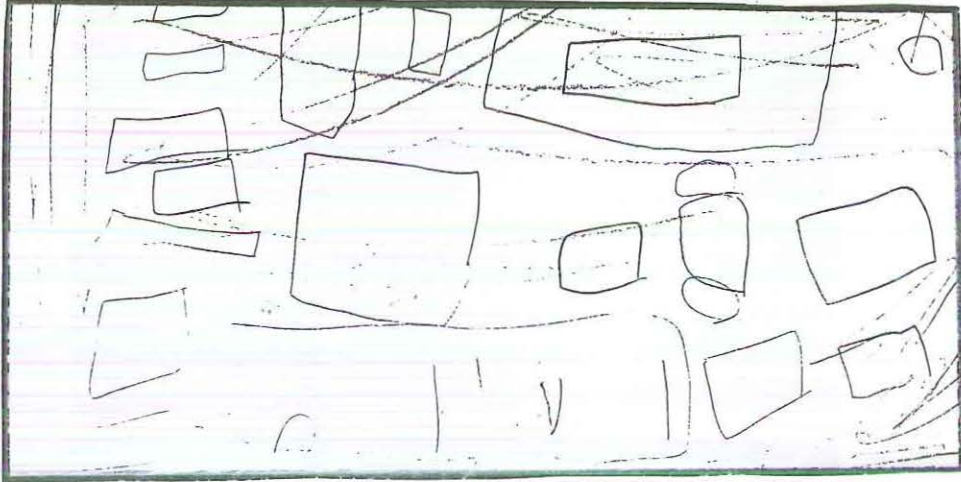
Myles: "This is (these are) the sides and this is the top. You lift this up and put the paper in and here's where the paper comes out."

Interestingly, during an interview with him at the end of the project he could not articulate his understanding of design, and it seemed he had learned very little. It may have been that Myles needed to have the concrete, design plan in front of him, in order to discuss the concept of design.

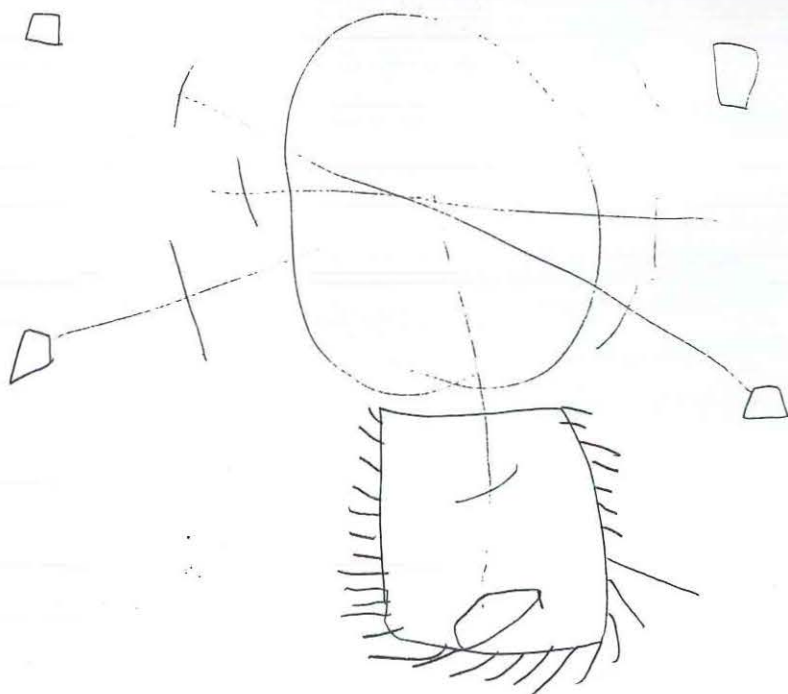
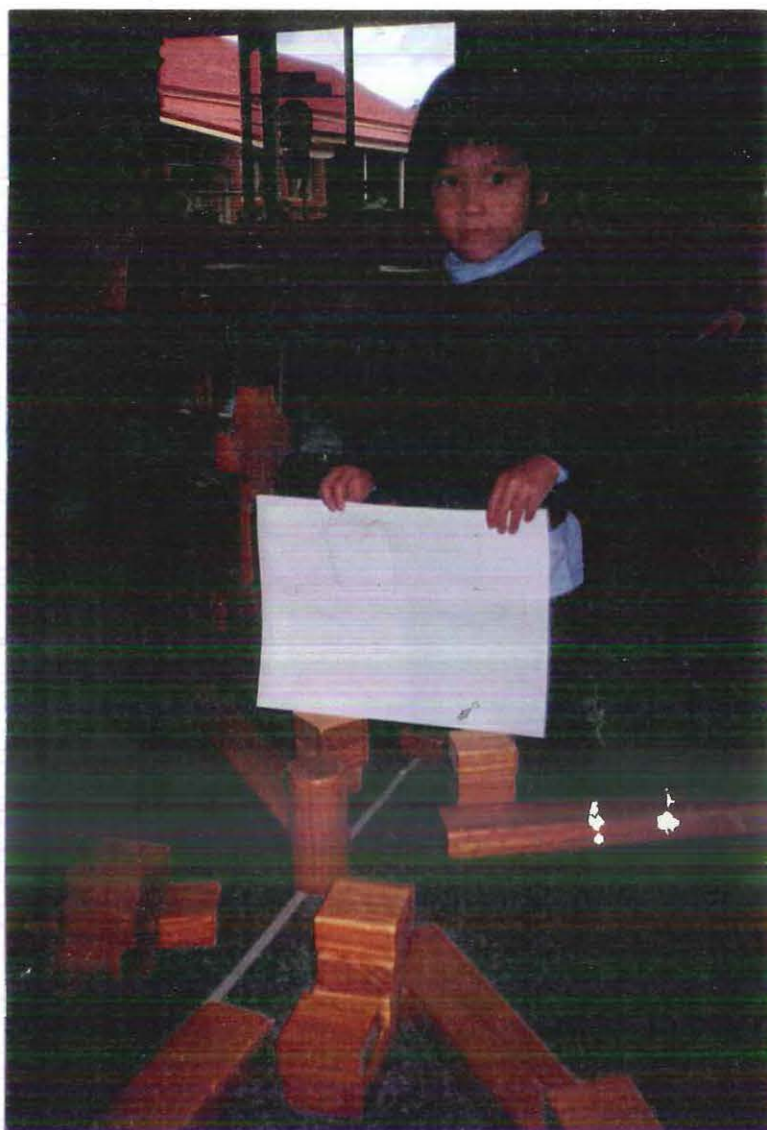
Other children designed a swimming pool, a helicopter, a robot, and buildings, and were able to discuss their design plans whilst pointing to relevant parts of the structures. It was interesting to note the different views of the various structures, depicted in the design plans.

Topographical designs drawn by Erin and Jeffrey were represented in the same way by the blocks.

Erin's swimming pool design and structure.

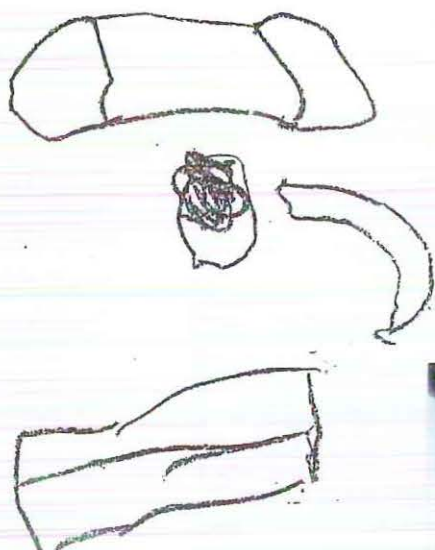


Jeffrey's helicopter design and structure.





This child's design plan represented the individual blocks she would use, rather than what the structure would resemble.



(Notice child in background referring to his design plan during the construction process.)

Tom's design plan was also a representation of the blocks he would use, rather than what the structure would resemble.



Interestingly, before the commencement of the study children were working cooperatively on projects and yet once "designing" began, children chose to work individually. In fact, children not involved in designing a particular design project, had difficulty understanding the anger of another when they added "their bit" to a building

under construction from a design plan. Some children were heard to say, "No! That's not right" and "It's not supposed to go there!" In these circumstances children were encouraged to explain what they were doing to children who were thought to be interfering. This strategy was not always successful as the children who had drawn the design displayed possessiveness towards their construction saying, "But it's my design!" and "But I want to do it by myself". At these times it appeared to the teacher that the sheer concentration involved in following a design plan was a difficult enough task for the child involved, without the added burden of discussing the design with another. This assumption was corroborated by the fact that the children seemed to dislike their concentration being interrupted by questioning and discussion with the teacher:

Teacher: "What are you going to do next, Joseph?"

Joseph did not answer, but continued looking at his design plan.

Teacher: "Do you know what comes next, Joseph?"

Joseph: "I'm trying to think and I can't concentrate with so much noise around."

On this particular occasion, the classroom was comparatively quiet as many children were playing outside. It seemed to the teacher that Joseph was asking *her* to be quiet. This scenario was repeated during the project by other children and their peers or their teacher and occurred during both the design and construction phases.

All focus children and some others designed and built structures during this period. They were filmed taking their design plans to the block shelves to choose blocks that corresponded with their plans. Children referred to their plans during the construction



process and when they were questioned as to why they were doing this, children often ignored the teacher or they answered "I'm checking to see if it's the same" or "to see what to do next".



### Step 9. Designing using junk materials

The next session involved children in designing projects made of other materials. First the whole class brainstormed possible projects. It had been decided that children would work cooperatively on joint projects. Possible projects were recorded on a whiteboard and a topic-web formed. The class was split into three groups, one group of ten children were required for perceptual motor activities, another group were involved in artwork outside and the teacher worked with the group of ten, <sup>no comma</sup> focus children involved in the project.



During this session the children appeared to be very focused and interested, which was shown by the many ideas for projects offered by the children. The possible projects on the topic web were narrowed into four categories - wheeled vehicles, hats, rockets and a hedgehog. Three children chose to design wheeled vehicles, three to design hats, three to design rockets and one child chose to design a hedgehog. The child who chose to design a hedgehog could not be persuaded to work with a peer, insisting that he preferred to work alone.

Because cooperation and collaboration is encouraged in the pre-primary, the teacher assumed that designing and building from design plans would be a collaborative activity. The teacher expected that during cooperative work the children would be more likely to collaborate thus providing examples of the thinking processes involved in the design process. However, this was not the case as during both the design and construction phases children chose to work independently and seemed too engrossed in concentration to converse with either their peers or the teacher.

### Designing Hats

Henry, Joseph and Myles decided to design and make hats. The teacher asked the boys to design a hat each and then work together to incorporate the best features to make one hat. The children drew their own designs as planned but did not want to incorporate the best features into one hat. Eventually they agreed to do it especially for the teacher. Designing and constructing the hat for the teacher took only two minutes. During this time the children appeared to be more interested in collecting materials for their individual projects. This led the teacher to believe that the children were thinking, "Let's do what she wants quickly and then we can get on what we really want to do."

They had to be continually re-directed back to the collaborative design plan as they were anxious to begin their individual projects. They worked very quickly, appearing to be throwing anything in sight onto the top of an ice-cream container. "There, that's yours." they said. The hat did not resemble the design plan at all, but at least it was finished and they had complied with teacher's wishes and they could begin their own projects.

The children then began their own projects with much enthusiasm. Two of the three hats bore remarkable resemblance to the design plans. Perhaps this was because the children were intrinsically motivated and had ownership of the project. Henry's hat bore no resemblance to the design plan although he asserted that it did.

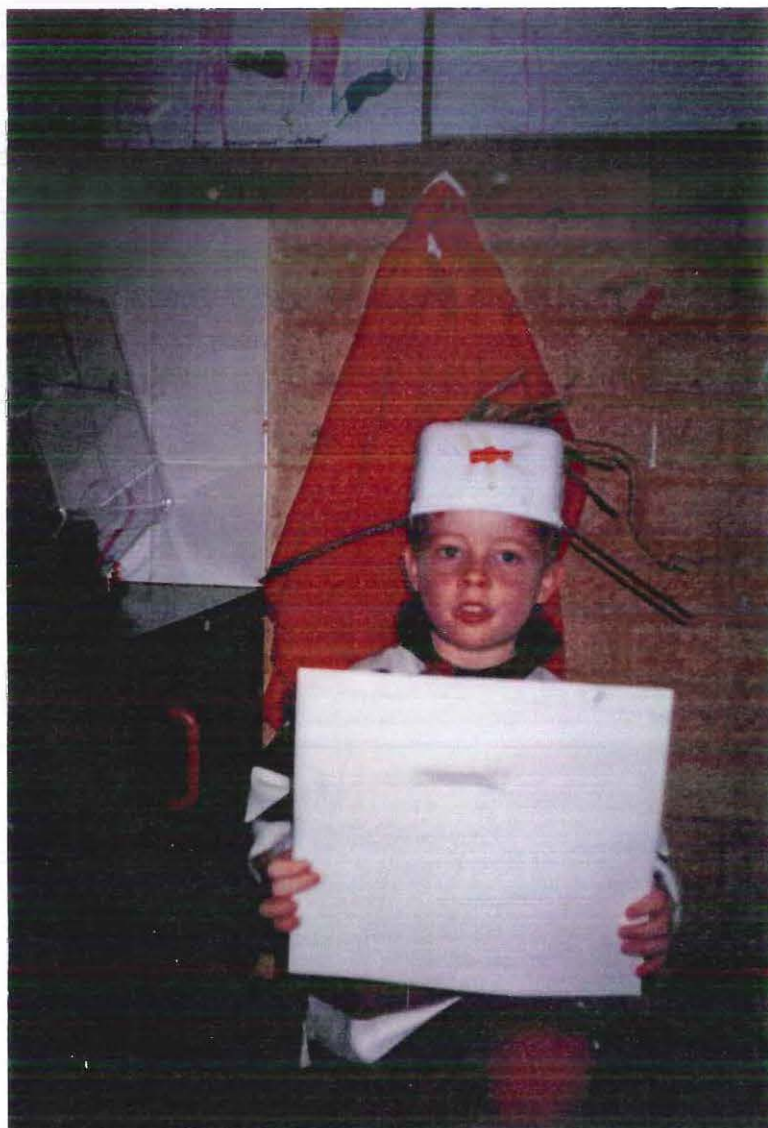
During the construction of the individual hats, children worked independently and did not converse even though they were sharing the same work-space and materials. It was very quiet and seemed unnatural, being an unusual contrast to the talk that generally accompanies their work.

Myles' hat resembled his design plan. He referred to his plan during construction and was asked what he was looking at. Mark replied "I'm just looking to see if it's the same." This showed that he understood the concept of design and that he could produce a concrete representation of his design plan.

Henry's hat bore little resemblance to his design plan although he claimed that it was an exact replica. The design was that of a "ghost hat" and a representation of a ghost could certainly be seen in his drawing. To the teacher, the hat was just an ice-cream container with bits of wool glued to the top although the wool pieces chosen were pale

blue and pale pink and light and fluffy in appearance. Perhaps this was Henry's way of representing his understanding of the intangibility of a ghost.

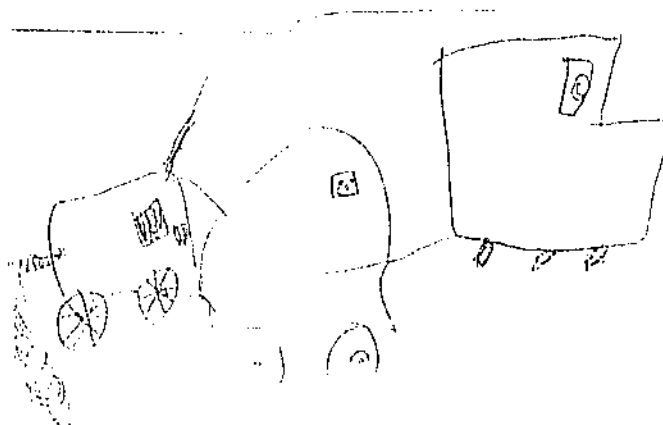
Joseph's hat was a good representation of his design plan. During construction he said "I'm just making a bow to make it look better." When the teacher asked whether the bow was part of the original design, he answered "No, but it doesn't matter." Joseph cut a bow from red paper and glued it to the front of the hat but made not attempt to amend the design plan.



## Designing Wheeled Vehicles

Jake, Erin and Rose decided to make wheeled vehicles and chose to make a car, a truck and a cart. The teacher asked the children to work cooperatively to build just one wheeled vehicle. During the designing of this project it was interesting to note that the children worked quietly. It seemed so unnatural as when not designing formally, the children talked all the time and shared their thoughts with others. It seemed as though the sheer effort of concentration during the design process did not allow for conversation. During the drawing process, children began to talk a little more. Children asked questions about the location of the engine; the function of the exhaust pipe; and the origins of the smoke.

The teacher had asked the children to work together to draw just one wheeled vehicle. Interestingly, they chose to draw their own vehicle as part of the total design. The children then attached the three vehicles together by drawing a line to each, with one vehicle appearing to pull the next. By attaching the vehicles in this manner the children had complied with the teacher's wishes by working cooperatively, yet at the same time had pleased themselves in not really wanting to work cooperatively in this project.



When designing this project, the children were not considering the materials available to them before or during the design process whereas during designing with blocks the children considered the blocks available for their design. The teacher encouraged the children to consider the materials they might use during the design phase but the children seemed uninterested at that stage. She then asked the children to go off and look at the materials available. One of the children went to the fastener shelf and brought back a range of fasteners whilst others brought back junk materials to begin the project.

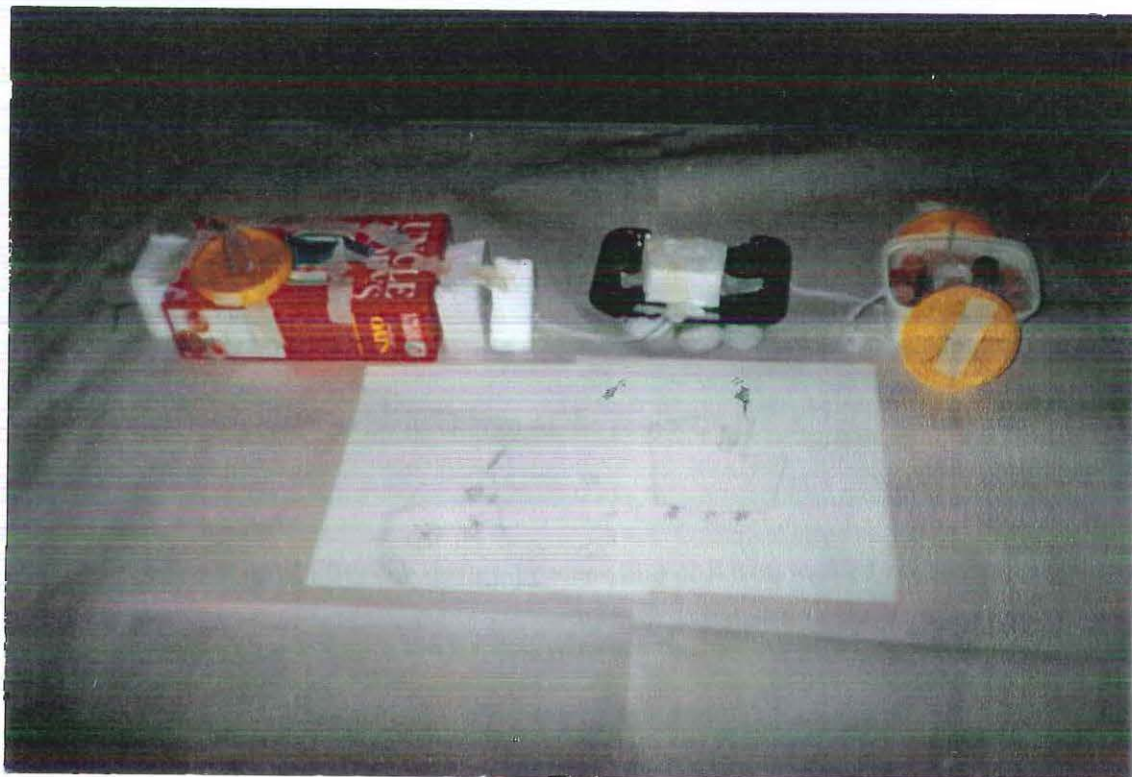
During this project, the rest of the class was involved in other self-chosen activities. Rose was very focused and seemed to know exactly how she was going to make her cart. She set about building it immediately. Jake began to fasten boxes together to make his truck and finally Erin began her car. It was interesting to note the children used the skills that had been developed the previous week.

Erin took a while to get going, and did not verbalise her thoughts. The teacher thought that she was less focused and interested than the other children in the project but she had a good idea of what she was doing and her car turned out well. During the construction process, the children appeared to be deep in concentration, did not converse with each and were unresponsive to prompts by the teacher.

Finally each of the children finished their individual components of the project and they set about attaching the vehicle together. They appeared to know exactly how they



would do attach them. At the completion of the project the structure and the design were compared. The owner of each component had very definite ideas about how it should be attached to the other.



The structure resembled the design remarkably and the children seemed very pleased with their work. Each child pointed out the part of the structure they had built. Rose said, "That's the cart" (pointing to the cart she had made) "and that's it on the design" (pointing to the cart in the design). Each child then pointed to the part they had designed and constructed. Rose then commented "and that's the string that joins them all together" pointing first to the string and then to the line in the design plan.

## Designing Rockets

The third project involved Mark, Seb and Jeffrey who chose to design and build rockets. The children in this project were asked to work together to build one rocket instead of three. They were asked to discuss it together and to think about what they were going to design and build. The children were encouraged to think about what the rocket would look like, how it would work and the materials needed to build it.

They worked together to design the project and seemed focused. The children discussed where different parts of the rocket should be. They decided that the rocket needed wings so it could fly. Mark seemed to take control saying he had a good idea, and that one child should make the satellite, one should do the main part of the rocket and that one should make the wings. Mark did not actually do any of the drawing of the design, even though he seemed to be in charge of the project.

It was not until after the design process that children looked at the materials to see what they might use to make the rocket, whereas during the block projects, children examined the materials during the drawing of the design. Perhaps this indicates that the design process continued during the construction phase when children were provided with a greater choice of materials.

During this project the children seemed quite focused. They discussed the reasons for the choice of certain of materials. For example, one cylinder was examined and found to be too heavy. Mark said to Jeffrey, "This one is too heavy. The rocket will never be able to fly." That cylinder was abandoned and a lighter-weight cylinder chosen.

At one stage Jeffrey was making the wings but Mark thought he was making the missile and said that it should be attached in a different way. Discussion followed and Jeffrey agreed that the wings should become the missile and to attach them length-ways instead of across. During the construction phase, the children were engrossed in discussion about what would happen at take-off, when the satellite broke away and at landing. The children collaborated more during the construction phase than in the drawing of the design phase.

It took a great deal of persuasion to keep these children thinking about their design plan. Children were more creative and less interested in their design plan during this project. Their attention had to be drawn back to the plan and although the completed rocket did resemble the design plan slightly, the construction continually moved further away from the plan even with teacher efforts to re-focus.

The length of this project was constrained by the fact that one video recorder had a broken belt and the teacher had to share the school video. It is common for children's projects to often continue over days but sharing the school video-recorder meant the children had to be encouraged to complete the project hurriedly. The rocket did resemble the design plan in that it had wings, a bottom and a middle section.

During the construction phase the children were more interested in the satellite that was not part of the original design. The teacher, eager to refocus the children's attention on the design plan, asked "Why are you spending all this time on the satellite, when it's not even part of the design?" Seb replied "No problem, I can fix that" and with that he amended the design plan to include both the satellite and the wings. This child had also



amended his block structure design after finding the blocks he needed for the original plan were unavailable. It seemed important to Seb that his design plans and constructions were the same.

### Designing a Hedgehog

Mitch had not attended a pre-school group of any kind before coming to pre-primary. He was not used to cooperative work and his social and fine-motor skills were not as developed as the rest of the class however, his oral language ability was well developed. Mitch decided he wanted to work independently to design and make a hedgehog. The teacher tried to persuade him to work cooperatively with another group but he insisted he preferred to work alone.

Mitch decided on and gathered the materials for the hedgehog before he began drawing the design plan. This was interesting, as it was the first time the teacher had seen children deciding on and collecting materials for a construction before the design plan had been drawn. It seemed that he needed to have the concrete materials before him in order to visualise the abstract design he was about to draw.

Mitch worked steadily pointing out similarities between the design plan and the hedgehog during the construction. Although his design drawing was limited by his developing fine-motor skills, Mitch's hedgehog did resemble the design plan in that it had three spikes. Mitch was certain that his hedgehog was a replica of his plan. He explained "There's the three spikes (pointing to the spikes on the design plan and then to his hedgehog) and there's the body (pointing again to the relevant components) and it walks standing up – like people do!"

When all ten children had completed their designs using junk-materials, they and other children in the class were encouraged to repeat the experience. Interestingly, although children made many constructions using junk materials, none of them chose to design first despite frequent prompts by the teacher, whereas many children chose to design structures using blocks.

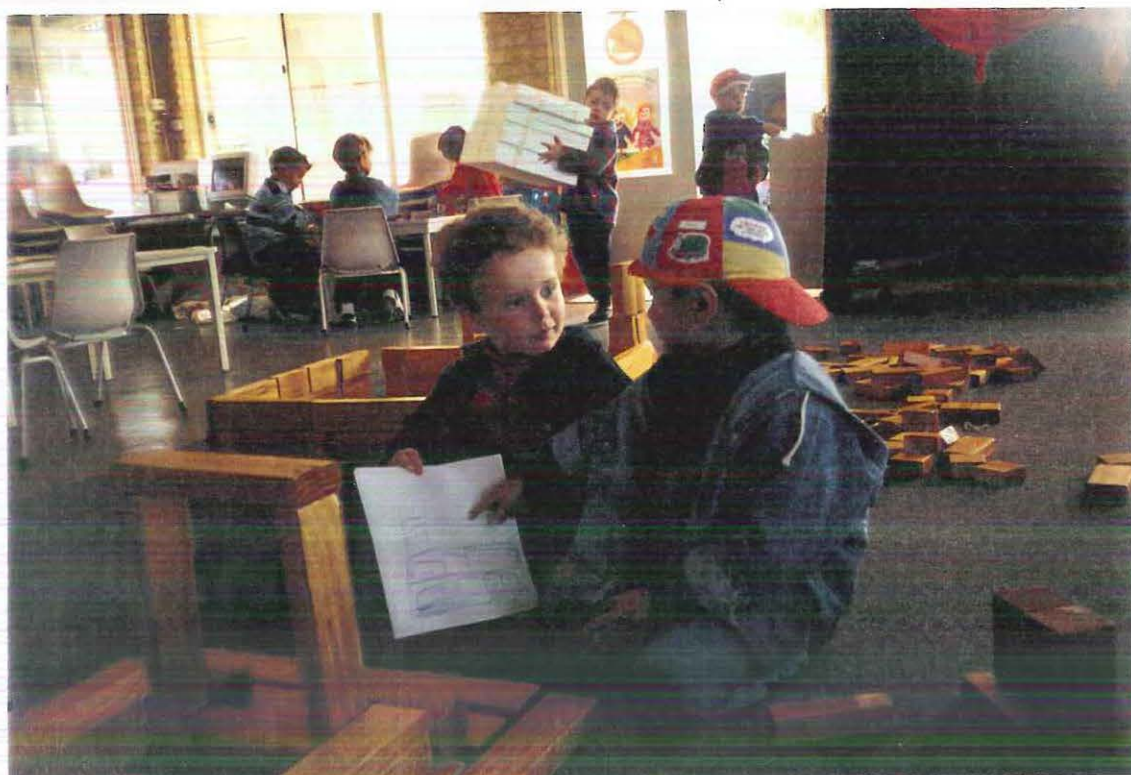
### Designing Continues

Over the next few weeks children continued designing and building structures using blocks. Children still chose to work independently on these projects although once, two children came to show the teacher a design they had created. Interestingly, they each had drawn their own design but must have collaborated during the process because the designs were the same and set about building the structure together.

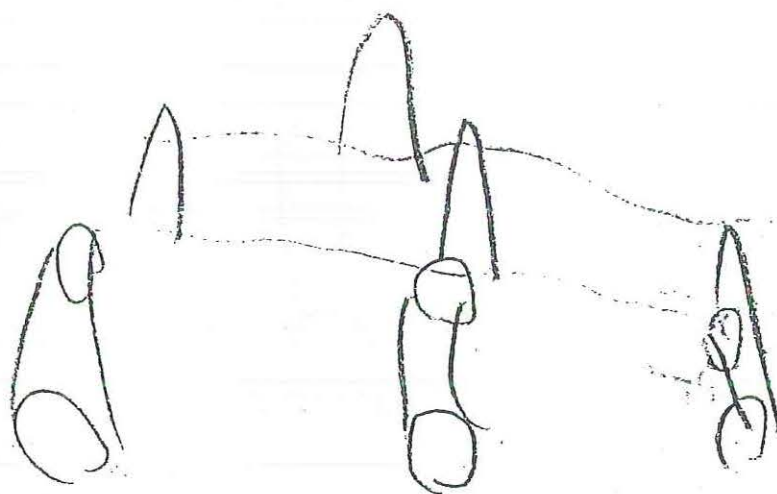
When asked whether the two designs were the same, one of the boys said "Yes" whilst, the other boy, a child for whom English is a second language, said "No", however with his limited oral language ability, he may have misunderstood and through that what was being asked was "Is it one piece of paper or two pieces of paper?" Or, "Is there one copy of the design or are there two copies?" During the construction of the building both the boys referred to their own design plans, indicating that they were in fact, both one and the same design.

During the weeks that followed, children were seen referring to design plans during the process of building. When questioned as to what they were looking at children indicated they were checking "to see if it's the same", or "to see what to do next", or "to

same” and “to make sure I’m using the same blocks as I drew in the design”. Children pointed out parts of the design plan and the pertaining parts of their structures.



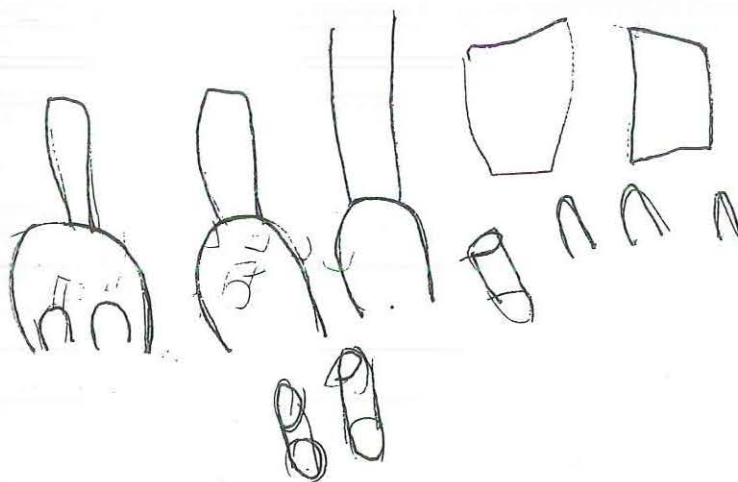
One child, Mark, built a block structure from a design plan in three parts. He produced three design plans during the construction phase. The first plan shows a view of what the completed structure was to resemble.



The second plan shows how Mark amended his original design by adding an arch shaped block.



The third plan was drawn last and shows the individual blocks to be used in the structure.





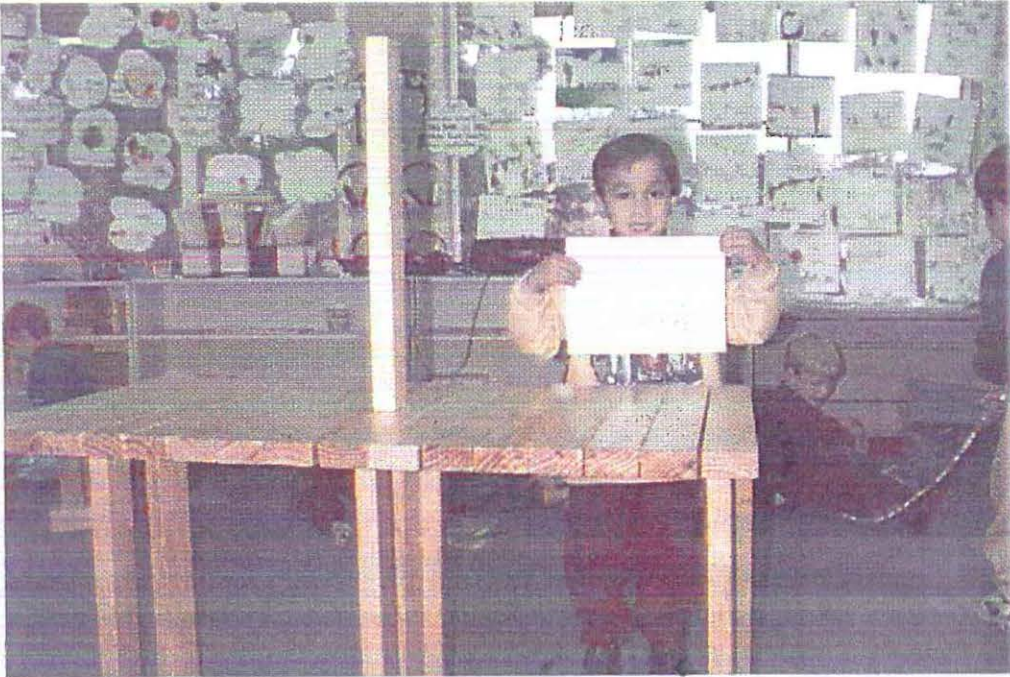
The third type of drawing mentioned, was used by other children at the beginning of the project. This type of drawing shows consideration of the materials to be used in the design rather than a vision of the project. Tom's plan showed the exact blocks to be used in his structure whereas Erin could identify some of the blocks used in the structure and shown in the plan, but there were also many others represented in the plan which were not used in the structure. Tom progressed to drawing many designs showing what the completed structure would resemble but Erin seemed to lose interest in designing.



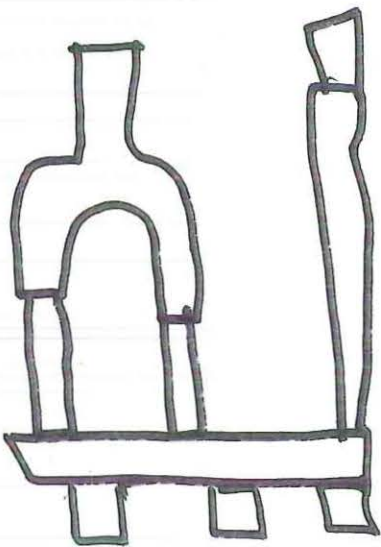
This photograph of Tom's design plan and structure shows how his understanding of "design" developed during the project.



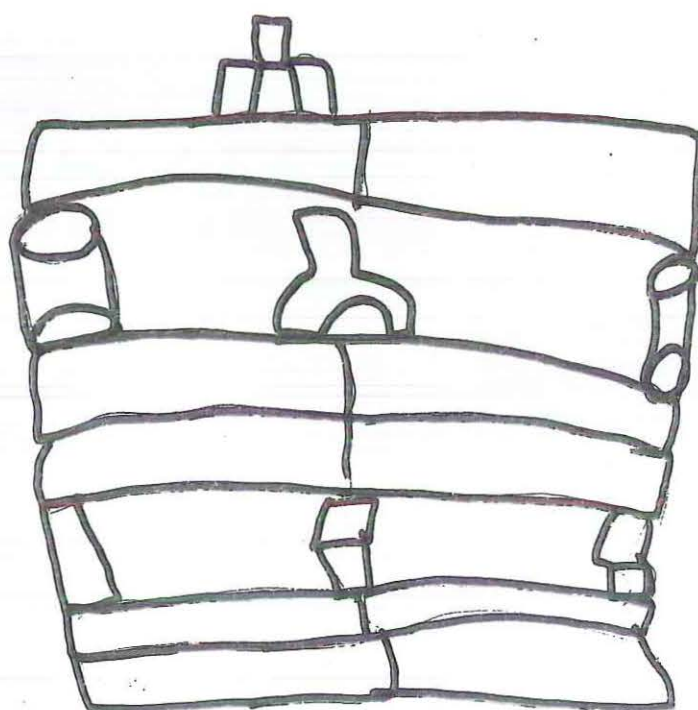
The following plans and respective photographed structures show the children's understanding of "design".



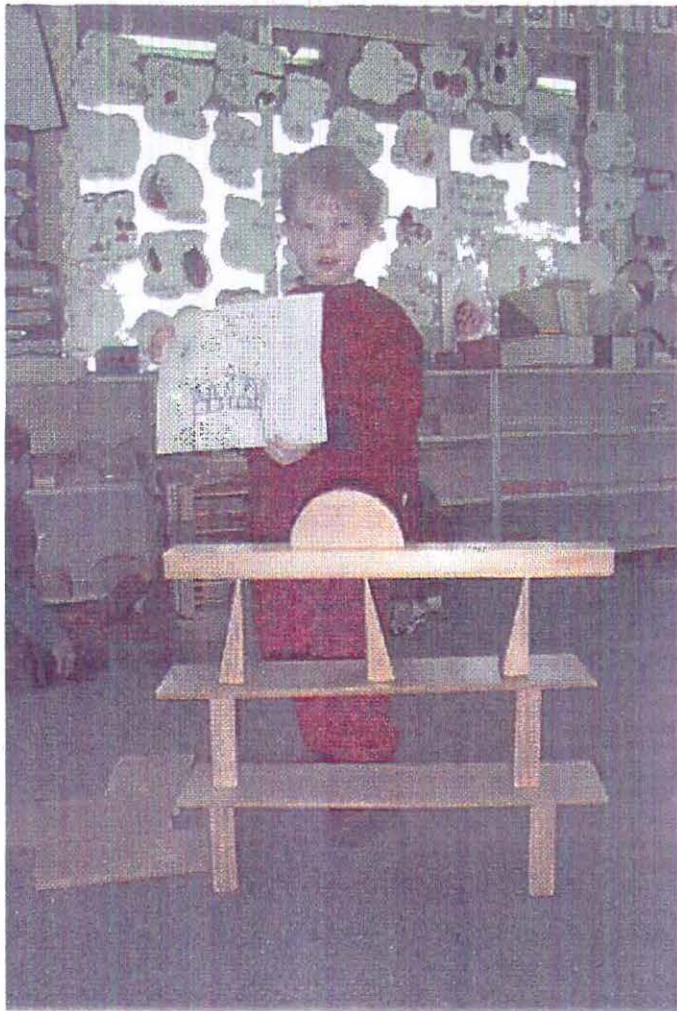
This photograph was taken from the "wrong" side of the structure but the design plan and building are very similar.



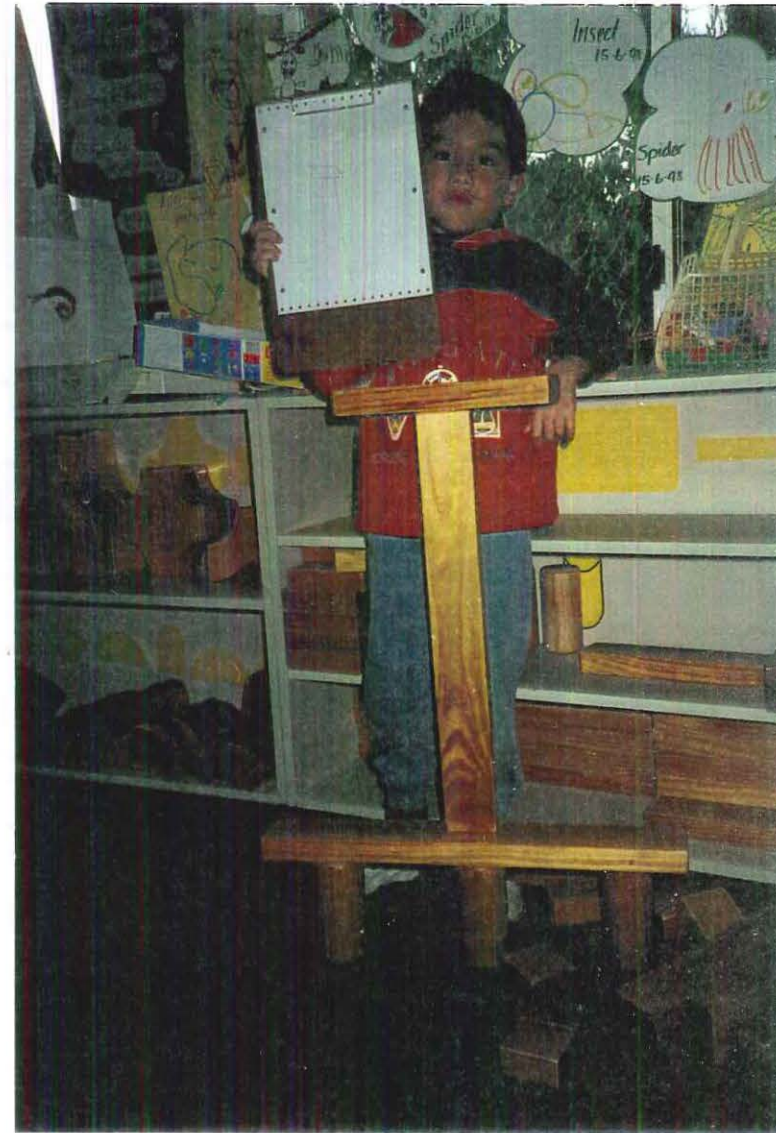
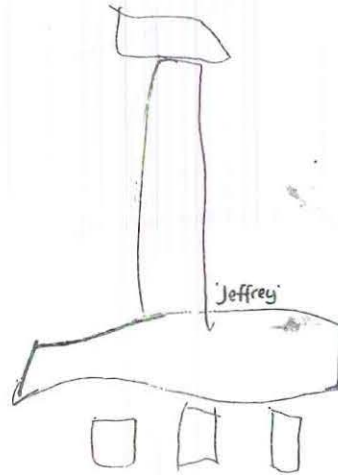
Rose's plan and structure bear a remarkable resemblance. Erin can be seen in the background building a structure. She was using her design plan to choose the blocks.







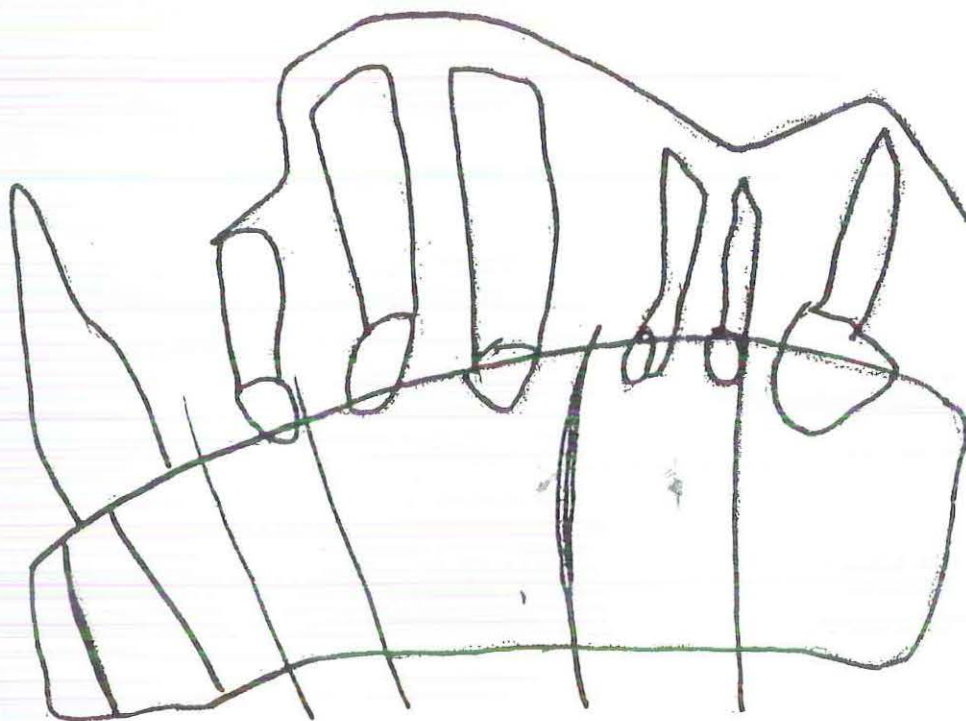
Luke's design plan and structure show his understanding of "design".



Jeffrey's structure was a good representation of his design plan..



The child in this photograph explained that he had to modify the building by using short rectangular blocks to substitute some of the column blocks as they were not available.



One morning, the teacher observed a child constructing a train. A little later the child presented the teacher with a design plan and asked her to look at his train. The teacher appeared delighted, but hesitant, as she had not noticed the presence of the design plan during the construction. She asked the child if he had drawn the design plan before or after construction. The child replied "I drew it after because I knew you would like me to give it to you. I designed it first in my head." It appears that this child's reason for drawing the "design" may have been his eagerness to please the teacher.

On the same day, another child, Jeffrey, called the teacher to see his "block design":

Teacher: "Where is your design plan?"

Jeffrey: "It's in my head?"

The responses of both these children, indicated they understood the mental processes involved in design.

#### Step 10. Analysis of individual interviews after the implementation of specific "design" learning experiences.

As shown in table 3, the final interviews showed that the children's knowledge and understanding of the term "design" had increased although children still demonstrated many differences in their understanding of the concept.

Child	Immediate recognition of term "design".	Confuses design and build.	Able to draw design.	Able to build from design plan.	Chose to design junk material projects.	Chose to design using blocks.	Stated preference designing block structures.	Discusses aspects of design.	Understands that design is a mental process.	Understands that drawing and designing are different.	Knows that drawing is not an essential element of design.
Mark	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Henry	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	?	No
Erin	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Joseph	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Jeffrey	Yes	No	Yes	Yes	No	Yes	?	Yes	Yes	Yes	Yes
Jake	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Seb	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Myles	Yes	No	Yes	Yes	No	Yes	?	Yes	Yes	?	No
Rose	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Mitch	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes

Table 3.

Children's understanding of term "design" after specific learning activities

Mark showed understanding of the difference between designing or planning and building. He preferred to design using blocks. Mark chose to do many designs using blocks but the only design using collage or junk materials he was involved in was the teacher-directed one. It seems that Mark may have been keen to please the teacher:

Teacher: "You've been doing lots and lots of designing, Mark. Why did you do them?"

Mark: "Because I wuv (love) you."

Henry still appeared to be confused about the term design, shown when he said design means "making things." However, he showed he knew that designing means thinking about options before making, saying "You have to think about it first...what you're going to make." He too preferred to design using blocks and chose to do many block designs. The only design using collage or junk materials with which Henry had been involved in was the one directed by the teacher for the study.

Erin showed an understanding of the difference between designing or planning and building.

Teacher: "If I ask you to design something what do you do?"

Erin: "You have to go and get a paper and pencil and go and do it."

Teacher: "But what do you do?"

Erin: "You have to know what you're drawing"

The last statement shows that Erin understands that designing takes place in the mind before drawing. She said that she prefers to design using junk materials however, at no stage did Erin choose to design, but she complied with the teacher's requests to design. When asked about her reason for designing, Erin said "I have to do what the teacher says." When asked why she did not like to draw her designs before construction (by

choice) Erin replied "Cause you have to look at other people's designs first and then come back." Erin's answer may be related to having to look at other's constructions and design plans during the drawing of her own designs, in order to assess the availability of blocks for her design. Availability was often limited as many children were interested in designing using blocks.

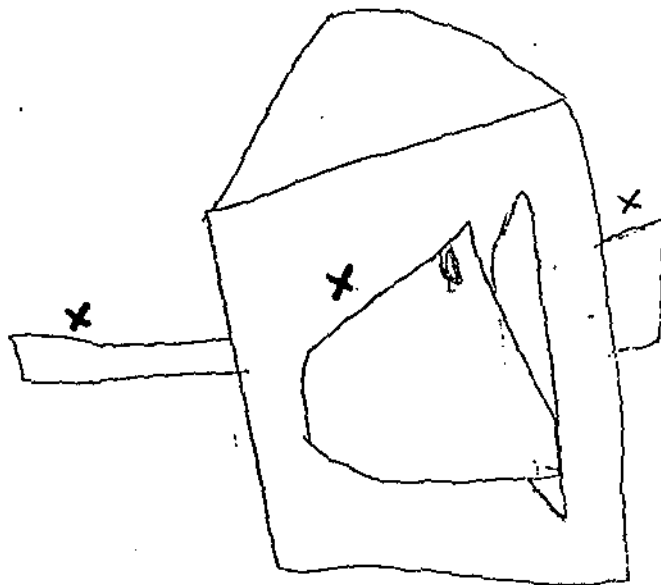
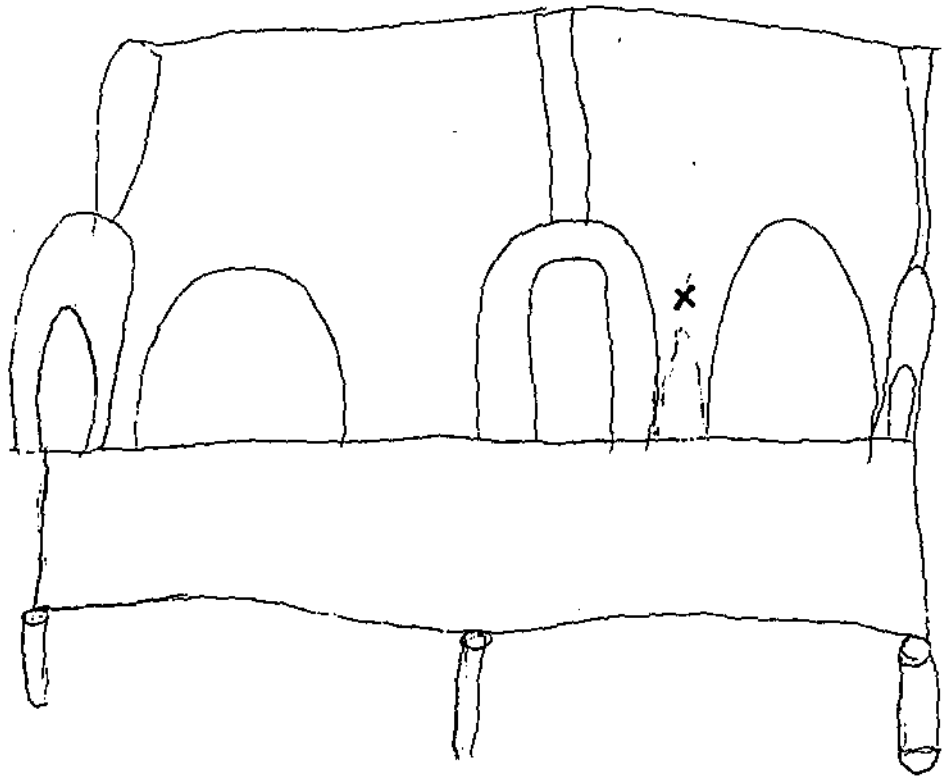
Joseph showed understanding between designing or planning and building. He showed a preference for designing using blocks by doing many designs using blocks. The only design using collage or junk materials in which he was involved was the teacher directed one. Joseph appeared to enjoy drawing design plans and building from them. He was aware that he was being filmed and loved to watch himself on the video. He continually asked to take the videos home to show his family, which may have motivated him to some extent. However, like many five-year-olds, he enjoyed positive feedback and this may have been a major reason for his many designs. Joseph presented his design plan for collection by saying "This is for you," with a hug and a smile and seemed delighted to gain the teacher's approval.

Jeffrey's first language was not English and he was quite unresponsive throughout much of the interview, which seemed very tiring for him. When asked why he had been drawing his designs before making structures, Jeffrey answered, "Cause I just want to" and when prompted further he replied, "Cause I just do". Jeffrey demonstrated his understanding that designing is a thinking process that precedes the building phase when he responded to "What do you have to do when you design?" by saying, "You go away and think about it."

Jake appears to have an understanding of design. When asked "What do you have to do when you design?" He replied "You write it first....you need to think about what you're going to 'sign (design) and you need to concentrate" Jake preferred to design using blocks, choosing to do many designs using blocks, and only participated in teacher directed junk design. It is interesting to note that he said the reason for designing was so that he could give the teacher the design plans. When asked why he chose to do so many block designs, Jake replied, "Yep, because I wanted to give them to you"(with a hug and a smile). He was aware that the teacher was collecting them and he seemed keen to please her.

Seb appeared to understand the difference between designing or planning and building. He embarked on the project with much enthusiasm. When asked why he chose to do so many designs he said "Cause I'm, *so* good." Seb emphasised "*so*" and he seemed keen to please the teacher. Seb said he preferred to design using blocks and chose to do many designs using blocks. The only design using collage or junk materials in which he was involved, was the one directed by the teacher. When asked about his preference for blocks he said, "Because it's a bit hard when I'm working with collage (junk materials)...sometimes it's a bit hard with both things." When asked whether he always designs before he builds, Seb replied "Sometimes I do and sometimes I don't", which may indicate that Seb thinks it is not always necessary to draw before building. For Seb, designing was sometimes a mental process continuing during the building process, which was shown when, during the construction process, Seb erased or added to design plans to "make it (them) the same" (as the objects he had built).

Seb's design plans show his amendments marked 'x'.





Myles was unresponsive during the interview.

Teacher: "What do you have to think about when you're designing?"

Myles: "You have to make it."

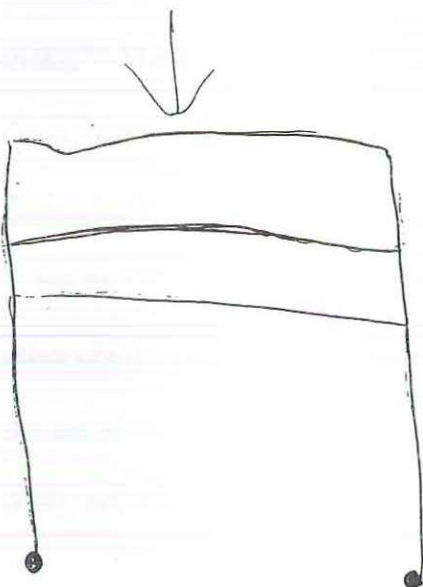
Teacher: "You have to make It? But what about the designing of it? What do you have to do before you make it?"

Myles: "I don't know."

Teacher: "When you are drawing the picture of the design, what do you have to think about?"

Myles: "Um..Um..I don't know."

It seemed that he did not want to think about designing at that time but Myles' design plan and structure (a photocopy machine) shown here, demonstrate that he understands the concept of design.



Rose understood the difference between designing or planning and building and understood that designing is the planning process that precedes building

Teacher: "What does it mean if I ask you to design something?"

Rose: "It means to make up something to build."

Rose understands that designing includes considering materials and thinking about the construction process. She displayed this when talking about design:

Teacher: "What do have to think about when you design?"

Rose: "You have to think about what you're going to use and how you're going to make it."

Rose said that she preferred to design using junk materials however, she too chose to do many designs using blocks and only one, teacher-directed design using collage or junk materials. Rose was aware that the teacher valued collecting design plans and was filming and photographing children involved in the process, which may have been a motivating factor for her many designs.

Mitch showed an understanding of the difference between designing or planning and building when asked "What is design?" He replied "the design that you're going to make." Mitch only designed when directed to do so by the teacher. He completed one design using junk materials and one design using blocks. When asked, "Why don't you design before you make?" He replied, "I don't like drawing it first", which may be linked to his fine motor skill development as it is less developed in comparison to most of the other children in his class. Mitch showed that he realised that designing and drawing are not the same thing and that one does not have to put the design on paper in order to have designed, when he said he "designs things in his head." It was also interesting to note his



reason for designing on paper as "Because I have to do what you say", which was evident as Mitch only participated in teacher-directed design activities.

At the end of the study, all ten focus children immediately recognised the term "design" and none of them confused the terms "design" and "build", compared with only three children at the beginning of the study.

All focus children were able to show they understood "design" to be a mental process and were able to discuss various mental processes involved in "design". All but two of the children demonstrated their understanding that designing and drawing are different and knew that drawing was not an essential element of "design". One child said that he enjoyed the novelty of using paper to design before construction.

Teacher: "What have you learned about design now?"

Mark: "Um..that sometimes you don't have to plan on paper....you can just think it in your head."

Teacher: "What made you think of that Mark?"

Mark: "Um...just my brain knew that already."

Teacher: "Why have you been doing so much designing?"

Mark: "Because I just like to use paper 'cause I hadn't thought of that before."

Mark's comments seem perceptive and articulate, which demonstrates the differences in understanding of five-year old children.

Another child Jake, showed that he linked planning with design. He said he thought designing was good because "you can think what you can make...and you can

make things with *all* the blocks". Jake emphasised "all" which may indicate that he thought more about the materials available during the design phase. Jake's comment showed increased understanding of the concept of "design" when compared to his comments at the beginning of the study:

Teacher: "What do you do when you design Jake?"

Jake: "I colour it in."

All ten focus children (and all other children who attempted design activities) were able to draw a design and construct from the design plan. One child amended his design plans on two occasions, once erasing a block which was available at the time of designing, but unavailable at the time of construction. On another occasion, this child amended a design plan by the addition of "wings and a satellite to a rocket" which were not included when the design was planned but were added during the construction phase. Children were also filmed taking their design plans to the block shelves when choosing blocks, and they articulated clear reasons for doing so:

Teacher: "Why do you have the design plan with you?"

Joseph: "So I know what I need."

Teacher: "Can I look after that paper for you while you carry the blocks?"

Mark: "No. I need to know what to do next."

Two children were also seen collaborating on a design plan during the construction phase which indicated that both children were able to follow the same plan.

Three of the ten focus children stated they preferred designing using junk materials, but they chose to do many designs using blocks whereas the only collage or

junk materials designing in which children engaged, was a result of teacher prompts and requests.

Interviews preceding specific "design" learning experiences indicated only three of the focus children had any understanding of the term "design". Two of these children were the children of engineers and may have heard the term at home. Seven of the ten children, appeared to have little understanding of the term "design." For example, in response to the teacher's question, "Tell me what design means," in the first and final interviews, these seven children replied:

First Interview Responses	Final Interview Responses
Henry: "Good...to be good."	Henry: "Making things, drawing, thinking first."
Erin: "To do it straight away."	Erin: "You have to get a paper and pencil and go and do it...you have to know what you're drawing."
Jeffrey: "I don't know."	Jeffrey: "You go away and think about it....something to make."
Jake: "I don't know."	Jake: "Um...you write (draw) it first you need to think about what you're going to 'sign (design) and you need to concentrate...you need to think what you need to make"
Seb: "I don't know."	Seb: "I think of things to make."
Myles: "I don't know"	Myles: "You have to make it."
Mitch: "I don't know"	Mitch: (When you design) "you have to think it in your head...um...the design that you're going to make"

Figure 2. Comparison of interview responses

Interviews held after the implementation of specific "design" learning experiences showed that all focus children understood the term "design" with the children

demonstrating understanding. Mark discussed his new-found discovery that designing could be a mental process:

Teacher: "What have you learned about design, Mark?"

Mark: "Um...that sometimes you don't have to plan it on paper...you can just think it in your head."

Jeffrey was quite unresponsive during the interview with the teacher, however his ability during design activities demonstrated his increased understanding of the concept of design.

The final interviews show a marked development in understanding of "design" of these five year old children at the end of the planned "design" learning experiences. It seems that the increased recognition of the term "design" was related to the "design" learning experiences used during the project.

### **Ten weeks on**

After a two-week term break and eight weeks into the next school term, designing emerged spontaneously in the children's self-selected learning experiences. During the preceding ten weeks the teacher had seen no evidence of designing by the children.

The designing appeared to have been triggered by the introduction of a small greenhouse into the pre-primary centre. The green-house was immediately taken over by children for use as a home-corner. The pre-primary home-corner had been put away to make room for the technology project and had not yet been returned. The following morning, one of the focus children, produced a design plan for a cubby house. When questioned about his reason for designing, Mark replied,

Mark: "Because I knew that the girls would like it."

Teacher: "Which girls?"

Mark: "The people, the girls who like to play mums and dads."

Teacher: "So you thought they would like a home corner because we have put ours away for a while (for the technology project)?"

Mark: "Yes"

Mark discussed his design plan with the class, pointing to relevant parts of the design as he went:

Mark: "Well, there's the climbing frames, and the balancing beam and the planks. Well if you use all the climbing frames and the long mattress, the balancing beam and the skipping ropes tied onto one of the bars of the climbing frame and the balancing beam, four planks, that one there's for a ladder, for stairs to get up, that one, for a platform, that one for a roof for people to stick the chimney in case it falls off, and that one there to support that one and to make sure the whole cubby doesn't fall down and a witch's hat for a chimney. It will be held by those things that hold the beam onto the bars and we can tie knots for the balancing beam to be held on and we can use all kinds of stuff to hold things together...and we can even have passwords."

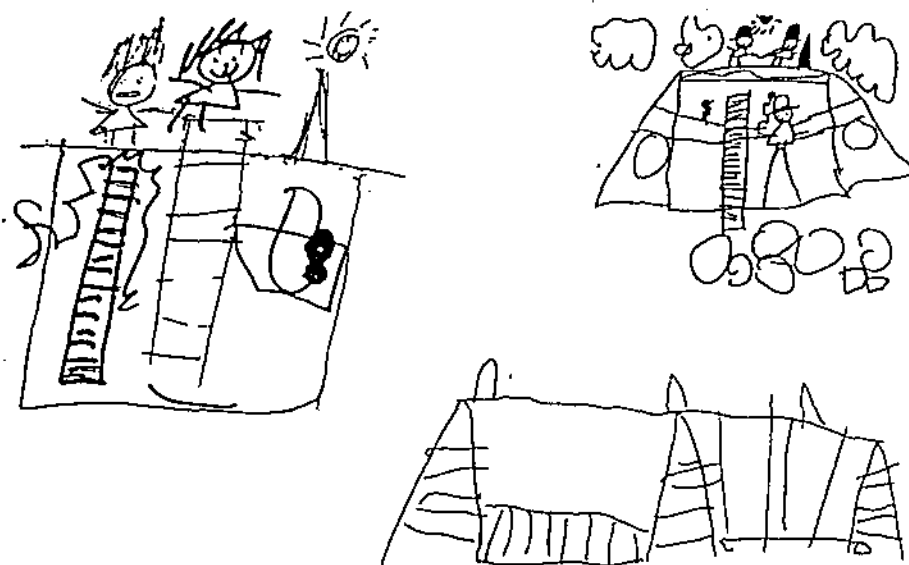
Teacher: "Will we have to take the design plan with us".

Mark: "Yes, in case we forget what it's meant to be like. I need a design so that I can remember."

Teacher: "And will you only look at it when it is finished or will you look at it when you are building?"

Mark: "Well if people forget, they can just go and look at it. We can just stop for a minute and look at the plans and start building again".

Mark's design plan was followed and the cubby was constructed with the help of most of the other children. During the week, many more children produced designs for cubby houses. Children were able to articulately discuss and construct their designs, demonstrating their developing understanding of design.



### Summary

The children had been able to transfer their learning, thus generalising their knowledge and understanding. Children were demonstrating understanding and knowledge of design to include thinking, planning, imagining, visualising, decision making, drawing, materials, construction techniques and tools. They showed they understood that design plans are used to inform oneself and others.

At the time of the writing of this paper, observations show children continue to incorporate "design" and technological language into their self-selected activities. For example, one child showed the teacher a "book of designs" that he had made whilst another group of children worked together to design and build a "boat to make an expedition to catch the Loch Ness monster" complete with designs for a "trip cage" and "technological equipment".

## DISCUSSION

This study explored the development of children's understandings of the abstract concept "design" which may present difficulties for children and teachers. In addition, it explored the use of technology as a vehicle to support a social constructivist approach to learning in the early years curriculum.

The need to develop teachers' skills to implement Technology and Enterprise in the classroom and the ability of young children to understand the abstract nature of the term "design", leads to the following question: "Do technology learning experiences help five-year-old children to understand the abstract technological concept of 'design'"? The study examined children's understanding of the concept of design, before presenting children with specific technological learning experiences and it investigated changes in children's knowledge after several week's experience with the concept.

Technology and Enterprise experiences aim to develop learning through the teaching roles of facilitating and scaffolding, which occurs as a result of the teacher's assessment of children's understandings. However, prior research, shows that teachers are unsure as how to assess children's thinking (Anning, 1994; Ebbeck, 1996; Low, 1995; & Oldfather, 1994). The present study gives insights into children's understanding about "design".

At the commencement of the study, most of the children appeared to lack an understanding of the concept of design. Piaget stressed that young children's thinking is tied to concrete, first-hand experiences. Design is an abstract concept and this study

showed that most five-year olds appeared to have had no experience with the concept, or of the term "design". It seemed they could not make links to their own experience about design and they appeared disinterested and off-task during whole-group discussions.

As the project progressed, children were presented with concrete, learning experiences such as examining their clothing design and exploring their environment. Concrete learning experiences that are personally relevant allowed the children to generalise their knowledge of "design". First-hand experiences allowed children to explore the materials with all their senses and encouraged children to verbalise their ideas with others.

Findings show that there was a difference in children's initial and developing understandings of the concept of "design". At the end of the study, children were able to discuss and construct designs, which demonstrated their developing understanding of the concept. In addition, children generalised their knowledge to a novel experience, which was shown by the cubby house designs ten weeks after the end of the project.

### **Cognitive Development**

The current study examined the implementation of technology in a social constructivist learning setting. Links are made to Piagetian constructivism with Vygotsky's social constructionist theory, which asserts that knowledge is rooted in social interaction. It examined five year old children's understandings of the concept of "design" and their ability to construct their knowledge as a result of interactions with the physical and social world.



The findings of this study support the proposition that cognition leads development (Berk & Winsler, 1995), which was shown by the children's increased abilities to design plans and make complex structures as a result of the teacher's facilitating and scaffolding of the children's developing understanding of the concept of design. The open-ended experiences allowed the teacher to assess the children's zone of proximal development and therefore work within it. The children's intellectual attainments varied, requiring different levels of scaffolding. For example, one of the children in the study, Mark (the child of an engineer), had been involved in specific design activities related to the building of a tree-house at home. The importance of first-hand concrete experiences was shown by his ability to function at a higher cognitive level when discussing "design" than some of the other children.

Vygotsky stressed the importance of child-teacher discourse in the scaffolding of children's knowledge (Berk & Winsler, 1995). In this study the teacher used scaffolding during dialogue to check children's understanding and to have them verbalise their thinking. During discussions, Vygotsky's "dynamic assessment" (Berk & Winsler, 1995) was used by the teacher to hypothesise about and respond to children's different cognitive levels using different levels of questioning in order to create increased levels of understanding. The varying levels of cognitive attainment became apparent during teacher questioning and responses. For example, during interviews with children to assess each child's understanding of the concept of "design", children demonstrated different understandings by their responses to questions. During discussions with the child mentioned previously, Mark, who had first-hand concrete experience with "design" the levels of questioning were higher, being "evaluative", than those directed to another

child Jake, who appeared to have little personal experience with the concept of "design" and responded only to "literal" questions:

Teacher: (during discussion about the tree-house) "You did make plans for your tree house but your dad didn't use those plans? I wonder why he didn't use those plans?"

Mark: "Because they would make the tree house too heavy and it...(the tree-house) ...might fall down....but it's attached to the tree...."

Teacher: "What do you do when you design, Jake?"

Jake: "I colour it in."

Teacher: "You colour what in Jake?"

Jake: "...in my book."

Teacher: "What sort of things do you make at home?"

Jake: "Aeroplanes."

Teacher: "So if you were going to make an aeroplane, what would you do before you made it?"

Jake: "You get some wood....and then you bang it."

It was apparent from the discussion with Jake that further questioning about his present understanding may have been of little benefit without first giving him some first-hand concrete experiences. The findings of this study support the importance of child-teacher discourse in determining both the children's actual level of development and their zones of proximal development.

The importance of the socio-cultural context in the child's construction of knowledge was emphasised ten weeks after the end of the project, when children designed cubby houses to fulfill a self-perceived need by some of the children, for a "home-corner" that had been put away to make room for the project.

In this study, design activities were found to provide a valuable pathway to social constructivist learning. Design activities fostered social constructivist teaching principles by presenting children with an opportunity to explore materials and to interact with teachers, adults and peers to clarify their knowledge and extend it further.

The present study emphasises the importance of teacher modelling as a powerful strategy in developing metacognition and in teaching young children to design. Demonstration of skills and teacher self-talk allows children to see the relationship between thinking and actions.

Metacognition is associated with successful learners (Wilson & Jan, 1992) and is developed during design activities which enable children to monitor their own thinking processes. This was demonstrated during teacher-modelled, block design and construction, by children who went to the block shelf to pass the next block needed to the teacher, showing that they had been able to read and follow the plan for the building. Metacognitive processes were shown again when Mark discussed his new-found discovery that designing could be a mental process:

Teacher: "What have you learned about design, Mark?"

Mark: "Um...that sometimes you don't have to plan it on paper...you can just think it in your head."

Self-initiated design activities allowed for children to learn, represent and utilise their knowledge using different media. Reggio Emilia's social constructivist philosophy is underpinned by the view that a child is a competent and complex social being who is motivated by and learns from social interaction and relationships with others. Children in this study demonstrated competence when working within their zone of proximal development, on cognitively demanding design tasks, and by showing persistence in the face of difficulties. It is interesting to note that in Reggio Emilia, teachers have high levels of expectations for competence from their students and the students produce work consistent with their teachers' expectations.

In this study, first hand experiences helped children to store relevant information in their long-term memory and retrieve it appropriately. This process was seen at the completion of the study, when children demonstrated the ability to transfer their learning, thereby, generalising their knowledge and understanding. Children demonstrated understanding and knowledge of design to include thinking, planning, imagining, visualising, decision making, drawing, materials, construction techniques and tools. They showed they understood that design plans are used to inform oneself and others.

In the present study, the concentration required by the children for self-initiated design tasks often seemed taxing, and yet children persisted to satisfy what seemed to be an intrinsic drive to learn. Children in this study required repeated "design" experiences in order to allow time for thinking, planning and designs to emerge. It is therefore

important that teachers develop children's cognition by providing them with lots of time, and activities that are intellectually, socially and physically stimulating.

It seems that children's responses to the design process relates to their level of cognitive development. For example, Mitch linked drawing with the finished product but not with the design process. He decided on and gathered the materials for his junk-material project (the hedgehog), before he began drawing the design plan. It seemed that he needed to have the concrete materials before him in order to visualise the abstract design he was about to draw. Possibly, having the materials in front of Mitch might have freed him cognitively to take on the more demanding and abstract concept of design.

During the project, children were very successful with block structure designs and seemed to enjoy the experience. This study was conducted half way through the school year, and the children's apparent ease of designing block structures, may have been due to their familiarity with the blocks at that time. This finding supports the earlier work of Dockett & Perry (1996) who assert that children learn most successfully when they build on their prior knowledge. Another factor affecting the success of block designing may have been that the blocks were stored in such a way that the children could see exactly which materials were available for the design, at a single glance, providing them with a synoptic view. The use of blocks then, might be seen as freeing the children to function at high cognitive level, within their zone of proximal development, whilst working with a familiar, concrete media, with which they had much experience.

Children in the present study were self-motivated to do many designs using blocks, but were only involved in teacher-directed collage or junk material designing. One reason for the children's preference for designing block structures, may have been the need to make more decisions when choosing construction materials from the huge choice of junk-materials, available to them. The apparent ease of designing block structures may have been related to the minimisation of cognitive overload by the limited choice of materials, which were the blocks on the shelves.

Stroud (1995) supports the contribution of block play to a child's physical, social, emotional and cognitive development. Stroud (1995) states: "block play contributes to cognitive development by describing the problem-solving activities, scientific principles, and mathematical concepts associated with constructive play. However, scant attention has been given to the relationship between block play and literacy development" (p.9). Stroud further states that designing and constructing block structures can be "representational and serves as an introduction to symbolization; the blocks themselves become symbols for other objects, just as printed letters and words are symbols for objects and ideas" (p.9). When children interpret their designs they are "reading" the plans, and it is inferred that this process facilitated their understanding of symbolic representation.

Designing block structures may help to prepare children to work with the abstract symbols of reading and writing as the plan takes the representation to the two dimensional level. Visual discrimination, may be enhanced by following a design plan as children select different shaped blocks, needed during the design and construction process. Stroud (1995) supports this assumption and asserts that children look at,

compare, and match blocks of varying shapes and sizes as they select blocks needed during the construction process, which provides opportunities to practice and refine the visual discrimination necessary for distinguishing similar letter and word formations during the reading process.

### **Psycho-social Development**

This study showed the importance of developing good teacher-child relationships. Children involved in this study regularly sought teacher support and positive feedback and responded eagerly to the teacher's requests. It is interesting to note that the reason given by some children for their many attempts at designing, was that they wanted to present design plans as a gift to the teacher. The children seemed keen to "please the teacher" and could see the teacher's obvious delight at their self-directed efforts at "design". For example, when asked why they chose to do so many block designs, one child replied with a hug and a smile, "because I wanted to give them to you," while another said "because I wuv (love) you".

The need to allow for individual differences, was shown by two children who were involved in the study but who did not seem to have the same need to please the teacher. These two children were involved only in teacher-directed design activities and did not extend their involvement with additional tasks.

A recent study by Pianta (1996) suggests that child-teacher relationships in the early childhood years have a crucial influence on the development of social, emotional and academic skills. Pianta stresses that "developmentally appropriate practice"

(Bredekamp, 1987) is, to a large extent, dependent on the development of positive child-teacher relationships in positive classroom environments.

Vygotsky's theory regarding the social nature of learning and instruction further supports the importance of developing good teacher-child relationships with his emphasis on history, and the importance of understanding the development of children's social relations over time. It is important that a teacher knows the children well in order to scaffold each child's learning effectively. Teachers need to be partners with children in learning in order to work within their zones of proximal development.

The variable social development of individual children was evident. Some children were filmed walking around with design plans, discussing designs and constructions with their peers and waiting patiently for blocks. At other times, children were not as cooperative. For example, children not involved in designing a particular design project, had difficulty understanding the anger of another when they added "their bit" to a building under construction from a design plan. Some children were heard to say, "No! That's not right" and "It's not supposed to go there!" In these circumstances children were encouraged to explain what they were doing to children who were thought to be interfering. This strategy was not always successful as the children who had drawn the design displayed possessiveness towards their construction saying, "But it's my design!" and "But I want to do it by myself". At these times, usual strategies did not work and it appeared to the teacher that the sheer concentration involved in following a design plan was a difficult enough task for the child involved, without the added burden of discussing the design with another. This assumption was corroborated by the fact that



the children seemed to dislike their concentration being interrupted by questioning and discussion with the teacher. It is possible that children were working at the edge of their zones of proximal development and needed full concentration in order to carry out the tasks they were attempting. An involved child gains deep motivating long term educative experiences (Laevers, 1993).

Communication involves the passing of ideas in the form of words from one person to another (Emmitt & Pollock, 1991). Communication may have been difficult for these children, as their understandings were formation stage, and thus not ready to be shared.

During the "wheeled vehicles" project, the children chose to draw their own vehicle as part of the total design. They then, attached the three vehicles together by drawing a line to each, with one vehicle appearing to pull the next. By attaching the vehicles in this manner the children had complied with the teacher's wishes by working cooperatively, yet at the same time had pleased themselves in not really wanting to work cooperatively in this project. The children replicated the way real-life, large projects are approached; large projects are broken down into sections to be completed separately. For example, jobs are sub-contracted in building a house before coming together to complete the collaborative project.

When the children were talking about "designing in their head", their eyes appeared distantly focused and usually turned to one side or even closed in the effort of concentration to block out extra-sensory stimulation which helped them to focus on the

cognitively demanding task. The teacher fostered the children's confidence and risk-taking by ensuring the children worked in their zone of proximal development and by scaffolding their learning.

Triangulation of data ensured that children's understandings were not misconstrued, which was helpful in the case of Myles. During an interview with Myles at the end of the project, it appeared that Myles had learned very little about the concept of design as he could not articulate his understanding of design. However, the teacher knew that this was not the case as observations showed that Myles had designed and followed the plan for the building of a photocopier machine. He had been able to discuss his design plan, and pointed to the relevant parts of the structure. Myles may have been able to articulate his understanding of design, if he had a concrete, design plan in front of him during the final interview.

It is possible that Myles understood more than he could explain. An advantage of making design plans is that sometimes children's thinking capacity exceeds their oral language ability. Children's understanding can then be represented by the design plan.

It is important that children are given repeated design activities and large blocks of time in order to develop an understanding of the concept of design. It is a concern that if the technology is implemented as a "time-slot" activity, experiences will be fragmented and of little benefit in developing technological understanding.

## **Skill Development**

At the beginning of the present study and before the commencement of project work, all children were instructed in the use of various fasteners, for example, different types of glue and its application, sticky tape, scissors and fastening devices such as split-pins, paper binders and paper clips. Many of the children had not seen some of the fastening devices before. Parents were invited in to help to teach the above-mentioned skills, which were considered important as teachers sometimes mistakenly assume that children are skilled in this area, whereas children need to be taught so that the use of these expensive consumables is optimised. Children in this study, benefited from being taught the basic skills needed in order to operate the tools correctly and safely and about the best use of adhesives for different materials which allowed them to work autonomously.

During the skill development activity, some equipment was found to be faulty, thereby hindering the children's autonomy. For example, the cutting edge of one tape dispenser was blunt, while the reel, holding the roll of tape in another kept coming out as the children tried to dispense the tape. The malfunctioning equipment led to frustration by the children and the parents, and lessened the children's interest in the activity, which demonstrates the importance of providing good quality equipment in good working order for technology projects.

## **Integration of Learning Areas**

In the present study, the implementation of Technology and Enterprise learning experiences allowed the integration of developmental domains to occur through a cross-curricular approach. Experiences provided vehicles in which the Catholic education

guidelines and the key learning areas (English, LOTE, science, technology, mathematics, the arts, studies of society and the environment, health and physical education) were integrated meaningfully and in context (Fleer, 1997).

### **Teacher's Role**

Anning (1994) found that as a recent addition to the early childhood curriculum, the implementation of technology may create difficulties for early childhood teachers who may be unwilling to try or accept changes to their traditional programs. The present study supported Anning's view that constraints such as prescribed curriculum, space, time, materials and support may hinder the successful implementation of technology in early childhood education.

For the teacher-researcher in this study, time and prescribed curriculum were not constraints due to a supportive principal who encourages current early childhood philosophy and shows confidence in her staff's teaching, planning and assessment ability by allowing a great deal of curriculum flexibility. The present study was facilitated by supportive teacher-assistants and much parental involvement in providing the children with the skills needed for the project and in planning and facilitating "design" tasks, which may not be possible or forthcoming in all early childhood classrooms.

### **Physical Amenities**

"Setting the scene" played an important role in the project as it appeared to create ownership and motivated the children to be involved in the study. Ensuring the accessibility of materials to the children increased autonomy, independence, responsibility and choice. "Setting the scene" allowed for Vygotsky's "socially shared

cognition" and children were encouraged to become actively involved in and take responsibility for their own learning.

In the present study, the classroom setting was itself a zone of proximal development. The zone of proximal development was created by "setting the scene" to facilitate quality interactions between peers and adults and by providing experiences and materials to stimulate self-selected activities (Wood & Attfield, 1996). Scaffolding was gradually reduced until the new zone of proximal development was identified.

Space may be a constraint in some early childhood classrooms. For example, in the present study the home-corner learning centre had to be stored away to make room for the project. However, store-room space was created by making materials readily accessible to the children by storing them in the newly created "work-shop". For some Western Australian early childhood teachers, classrooms are transportable and space might be a major constraint. Constraints created by cost and availability of materials was minimised in the present study by using building blocks and junk materials.

Findings of this study may help teachers to understand technology and enterprise, and how it can be implemented successfully in early childhood settings. The study used materials and resources found in many early childhood centres, and the learning experiences were similar to experiences often implemented. This study showed that a different focus can help the teacher to shape learning experiences in a way to include technology outcomes.

## **Reflections on Professional Development**

This study has made the teacher researcher more critical of research and about the research process. The teacher learned much about the importance of educational research in naturalistic settings and of the importance of knowing the students well. Action research allowed the teacher to generate knowledge in a bottom up approach to professional development (Burns, 1997).

This research provided insights into the teacher's own teaching. The teacher researcher found the need for discipline in making objective observations. For example, sometimes the teacher thought she knew that the children understood but that they were not able to demonstrate their knowledge. At these times, it would have been very easy for the teacher to assume their understanding and thus possibly skew the findings of this study. Validity and reliability were ensured through multiple sources of evidence of children's understandings by the collection of many work samples, video and audio recordings, photographs and anecdotal notes, which allowed for triangulation of data.

The importance of wait time and listening to children was emphasised in this study. At times the teacher thought that the children's conversations had diverged from the subject and brought the conversation to a close, only to find later when listening to audio recordings that she had misconstrued the children's conversations which may have led to meaningful conceptual understandings.

The need for authenticity and child-owned work in this research provided professional development for the teacher-assistants who had previously found difficulty in "standing back" and allowing children to work within their zones of proximal

development. The teacher assistants' abilities to make and report observations also developed during this study. They learned to report only what was actually seen and observations were dated, detailed and authentic.

### **Implications for future studies**

In the present study children were motivated to engage in many design experiences using blocks, but were only involved in teacher-directed collage or junk material designing. In this study the teacher modelled block design and construction but did not model junk material design and construction. If junk material design and construction was modeled in a follow up study, then it is possible that children may be motivated to design using junk materials.

It may be interesting for a future study to have one-non-participant, child observer present while another child designs. One child could play the "interviewer", whilst the other plays "the expert designer" and describes each process involved in the design and construction phases to the child-observer. This might allow a "window" into a designer's mind.

### **Conclusion**

The findings of this study suggest that technology is a effective vehicle for developing socially, contextually and culturally appropriate learning experiences. Malaguzzi (1993) stated that educators need to help children develop as thinking individuals by encouraging children to have ideas of their own. Successfully implemented design learning activities allow five year old children to accept responsibility for, and manage, their own learning by allowing them to make decisions, to

take risks, to solve problems and to assess and evaluate their own work confidently in a secure environment. Design activities allow children to represent their understandings in a variety of media.

This study provides clear evidence of children's different understandings and zones of proximal development, which indicate the need for individual and small-group experiences as opposed to whole-group, lock-step, fragmented activities. This study provides evidence that children gained from cognitively demanding and intellectually challenging learning experiences that are made possible through technology and the social constructivist approach to learning.



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## **APPENDICES**

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Letter to Principal requesting consent.  
Letter to parents requesting consent.

#### **Appendix B: Interview Schedule**



#### Appendix A: Ethics Clearance

Letter to Principal requesting consent.

Letter to Parents requesting consent.

Jeannie O'Sullivan

The Principal

Dear

I am seeking consent to carry out action research in my pre-primary class.

Technology and enterprise have been added to the early childhood curriculum recently. However, many early childhood teachers feel unsure about how to implement technology learning experiences with five year old children.

The study will involve all the children and will explore the development of young children's understanding of the technology process through project work. It will document children's different understandings and make links to theories of children's cognitive development. In addition it explores the use of technology as a vehicle to support the social constructivist approach to learning in early childhood education.

The study will involve triangulation of data gathered from children's interviews, teacher and teacher-assistant journaled observations and work samples. It will involve time-series-analysis which allows for children's dynamic, developing knowledge.

Transcripts will be made of audio recordings and observations and transcripts made from video recordings. Digital camera records of working processes will be annotated and work samples and journals documented. Observation notes and journal entries will also be documented. Student responses will then be analysed.

Assurance of anonymity of the children, the school and of information gained from the research is ensured by strict regulations set down by Edith Cowan University.

Yours truly,  
Jeannie O'Sullivan.

## Parents of children attending Pre-Primary at

Dear Parents,

I am seeking your consent to conduct research with your children in my pre-primary class.

The study will involve all the children and will explore the development of young children's understanding of the technology process through project-work. It will document children's different understandings and make links to theories on children's thinking.

Technology is about identifying and meeting human needs. It involves children in generating solutions to real-world problems. Children learn to explore, control and improve aspects of their own environment - children interact with their world and make decisions about what to do, how to organise their space and create the effects they want.

It is said that the skills required by people in the twenty-first century will differ to those traditionally taught over the past two decades. Some of these skills are; the ability to communicate orally, in writing and technologically; the ability to cooperate, collaborate and negotiate, the ability to think critically and solve complex problems efficiently and the ability to view the human experience and our constantly changing world from a global perspective. These skills are reflected in the new Curriculum Framework Technology and Enterprise learning area.

As you can see, Technology can be a very interesting and exciting way to learn and I'm sure the children will love being part of this project.

Assurance of anonymity of the children, the school and of information gained from the research is ensured by strict regulations set down by Edith Cowan University.

Please sign the document checklisting your consent in our Communication Book.

Many thanks,  
Yours truly,

Jeannie O'Sullivan.

Appendix B: Interview Schedule

## Interview Schedule

Date / /

Children will be interviewed in groups of three. The following factors will be considered during the interviews.

- Data will be collected in a pleasant and relaxed setting and the use of words, body language and facial expressions will be considered.
- Open-ended questions will be used to encourage children's continued thinking and risk-taking.
- "How" and "why" questions in response to student's comments will be used to encourage elaboration and deeper thinking.
- Children will be asked "how" and "why" they chose to do certain things.
- Children's own responses will be repeated or paraphrased to encourage continued thinking.
- Children will be asked "Tell me more about..." and "Why do you think that..?" asked in a accepting yet curious tone
- Substantial "wait-time" will be allowed for children's responses.
- Communicating a judgment about right or wrong answers will be avoided.

PROBE	CHILD'S NAME & COMMENTS			ANALYSIS
Tell me what the word "design" means?				
How do you know that?				
Do you know anyone who designs things?				

PROBE	CHILD'S NAME & COMMENTS			ANALYSIS
Tell me more about that.				
If I asked you to design something, what would you do?				
Why would you do that?				
Tell me more about that.				
Why do you think that?				
Why do you think that people design things?				

PROBE	CHILD'S NAME & COMMENTS			ANALYSIS
What do you think people have to do when they are designing things?				